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Congenital Deformities in the Region of the Foramen Magnum: Basilar Impression[1]

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BASILAR IMPRESSION, platybasia, and basilar invagination are terms used to designate a deformity of the bony structures about the foramen magnum. The basilar, condylar, and that part of the squamous portion of the occipital bone which surrounds the posterior part of the foramen magnum are displaced cranialward (1), the foramen magnum is irregular in outline instead of the usual oval shape, and most often it is smaller (2) than normal, with its margins directed upward into the cranium (3, 4, 5). The downward tilt or angle of the clivus with the horizontal plane is decreased (6, 7, 8); it is broad and flat, and the petrous portion of the temporal bone is pushed upward (7). The floor of the posterior fossa is thin (1, 7, 9, 10). There is a variable degree of fusion of the atlas with the occipital bone.

This condition, according to Grawitz (9), was first mentioned by Rokitansky (1844), but the earliest detailed description was by Virchow (1876), who collected all the known cases. Many specimens of this and lesser anomalies of the base of the skull and cervical spine have been described, and a number of clinical case reports of basilar impression have appeared in the foreign literature. In the American literature Chamberlain (11) has contributed to the subject, a short review has been published by List (12), and Schüller (13) has reiterated some of the material in his previous writings[2].

It is therefore quite obvious that, at least in this country, little attention has been paid to basilar impression. Cases are not being recognized because clinicians are not familiar with the condition and are diagnosing them incorrectly as syringomyelia, multiple sclerosis, cerebellar tumor, Klippel-Feil's syndrome, etc., fitting them, according to the variable symptoms and findings, into what seems the most probable category, often as atypical examples.

There has been much discussion in the literature concerning the etiology of basilar impression. Rokitansky believed that hydrocephalus was the cause, but although an associated hydrocephalus is found at times (6, 14), the relationship is not clear. It is more probable that basilar impression is the cause and not the effect

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[2] Since this was written additional reports have appeared: Gustafson, W. A., and Oldberg, E.: Arch. Neurol. & Psychiat. **44:** 1184–1198, December 1940; Wade, L. J.: J. Bone & Joint Surg. **23:** 37–43, January 1941; List, C. F.: Arch. Neurol. & Psychiat. **45:** 577–616, April 1941

of the hydrocephalus. Trauma, rickets, and Paget's osteitis have been given as the cause in some of the case reports.

Schüller says that basilar impression is most common in countries where it is the custom to carry burdens on the head, but Russell (15) finds it most common in Eskimo skulls. The evidence in favor of a congenital maldevelopment is so convincing that it is here assumed that basilar impression is a congenital anomaly, although it is possible that deformities simulating basilar impression may occur from other processes.

There are many varieties of anomalous development about the base of the occipital bone and the upper cervical spine, of which basilar impression is one of the more extensive. The other lesser anomalies may occur alone or in combination with basilar impression. These consist of defects in the posterior arch of the atlas, absence or fusions of cervical vertebrae (Klippel-Feil's syndrome), assimilation of the atlas, and "manifestations of an occipital vertebra."

Defects in the posterior arch of the atlas are not uncommon. They were found 26 times in 1,626 atlases (1.5 per cent) examined by Le Double (16). In the presence of other anomalies of the atlas, a defect in the posterior arch is even more common. Bystrow (17) found these posterior arch defects in 55 per cent of atlases which were assimilated with the base of the occipital bone.

The Klippel-Feil syndrome, or congenital webbed neck due to absence or fusion of cervical vertebrae, when associated with neurological symptoms is rare, but has been reported (18, 19). A review of these reports, however, leaves one with the feeling that they may have been cases of unrecognized basilar impression.

Many references are found, especially in the anatomical literature, to assimilation of the atlas and "manifestation of an occipital vertebra" (17, 20–28). Some cases published as assimilation of the atlas or occipitalization of the atlas are basilar impressions as far as it is possible to tell from the reports. Others may have been basilar impression but from the data given no definite opinion can be formed (18).

"Manifestation of an occipital vertebra" is a term used by Kollman in 1905 (21) to describe anomalous bony formations about the foramen magnum suggesting a fused vertebra. Such malformations were first described by Meckel in 1815 (29) and were reported by many others under various titles prior to Kollman's report. Bolk (22) explains "manifestation of an occipital vertebra" as an atavistic phenomenon. From comparative anatomy he concludes that the craniovertebral border is not fixed but that it varies about a normal, with a tendency in man to shift caudalward (atlas assimilation). If it shifts cranialward, that is in the direction of an older phylogenetic order, an elevation appears about the border of the foramen magnum; this is the condition called by Kollman "manifestation of an occipital vertebra." If the shift is caudalward, then there is assimilation of the atlas with the occipital bone, and the greater the shift the more atlas is assimilated. This explanation of Bolk for these anomalies has been widely accepted (17, 28, 30, 31). In high degrees of assimilation the fused atlas may protrude on the surface of the occipital bone to the same extent as the protuberance in "manifestation of an occipital vertebra." These two conditions, "manifestation of an occipital vertebra" and atlas assimilation, are therefore not always to be distinguished by the amount of bony projection about the foramen magnum, but by special features in the bony projection.

Assimilation of the atlas and "manifestation of an occipital vertebra" are most comprehensively discussed by Bystrow (17, 24). According to this author, the literature on assimilation of the atlas goes back to Columbus, a pupil of Vesalius, and the condition was again described by Morgagni in 1767. It is a rather common anomaly in museum skulls. Bystrow discovered 33 assimilations in 1,570 museum skulls (2.1 per cent), but in non-selected

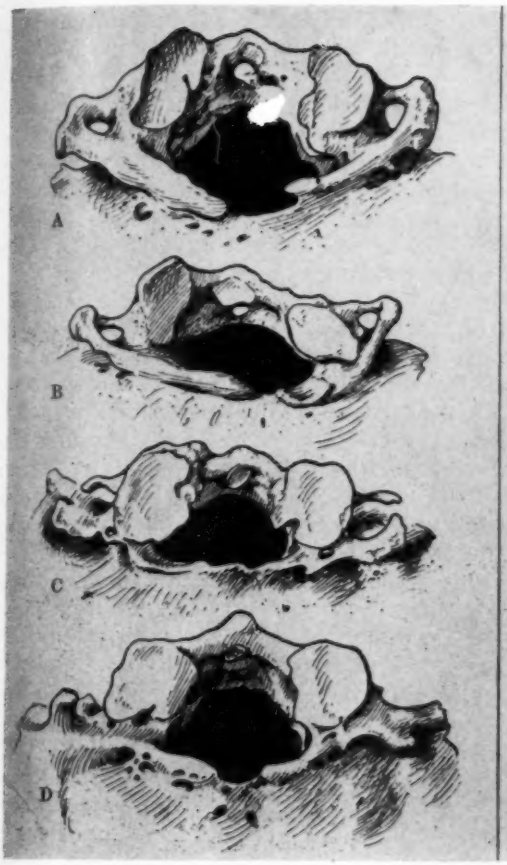

Fig. 1. Specimens of assimilation of the atlas. From Bystrow (17).

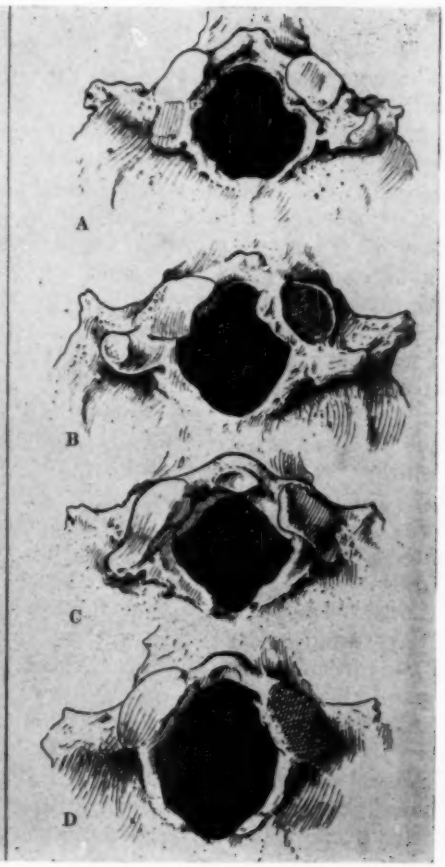

Fig. 2. Specimens of "manifestation of an occipital vertebra." From Bystrow (17).

skulls it is not as frequently noted; Friedlowsky (32) found an incidence of 0.2 per cent in 2,000 skulls, Russell (15) 0.4 per cent in 1,155 skulls.

Not all synostoses between the atlas and occipital bone are necessarily due to anomalous development. Lesions which produce synostoses of other joints may lead to the same result in the atlanto-occipital joint, particularly arthritis, tuberculosis, or trauma, but examination of the specimens of assimilation of the atlas indicates in almost all cases a developmental origin.

Assimilation of the atlas and "manifestation of an occipital vertebra," also called proatlas, may be similar so far as the size and number of elements present are concerned but they can be distinguished by the following differences.

1. The joint surfaces on the proatlas, like those of the normal condyles of the occipital bone, are so placed that if the planes of these surfaces are projected they converge caudalward, while the joint surfaces of the assimilated atlas are placed like the normal inferior articular surface of the atlas and, if projected, converge cranialward. This is the most constant and reliable differential feature (see Figs. 1 and 2).

2. In assimilation of the atlas there is almost always a foramen on each side between the posterior arch of the fused atlas

and the occipital bone, for passage of the vertebral artery and first cervical nerve in their normal relationship to the atlas and base of the occipital bone.

3. Other differences are more or less inconstant and unreliable. Frequent development of a paramastoid process and the presence of a canal between the anterior arch and occipital bone in atlas assimilation are given by Lanier (28) as differential features. According to Bystrow (17) a complete posterior arch has never been observed in "manifestation of an occipital vertebra" and seldom (6 per cent) is there even a well formed posterior arch. Of all the elements of a proatlas, he finds the most frequent manifestation to be the formation of some part of an anterior arch (67 per cent), but a complete anterior arch is rare, being present in only 15 per cent of the specimens in which an anterior arch appeared, and this arch is always more or less fused to the border of the foramen magnum, never completely separated.

All reports of basilar impression reviewed in which the specimen has been dissected and described indicate that assimilation of the atlas is a constant part of basilar impression, being found in every instance where the atlanto-occipital joint was examined (1, 6, 9, 20). In roentgen examination it is often difficult to determine the presence of a synostosis between the atlas and occipital bone unless body section roentgenography is used. The deformity of the assimilated atlas, however, is visible and the latter is reported as rudimentary, hypoplastic, or deformed (4, 33, 34, 35). It is also significant that in some specimens reported as assimilation of the atlas (25, 26, 27) there is a deformity in the shape and size of the foramen magnum, and even in "manifestation of an occipital vertebra" similar changes occur (24) (Figs. 1 and 2). This would suggest that all these conditions are related and that basilar impression is an extreme grade of a group of anomalies which may occur about the upper cervical vertebrae and base of the occipital bone.

The deformity of basilar impression may be present without neurological symptoms (9, 11, 20). As a rule, symptoms do not develop until adolescence or late in life but when they do appear they are slowly progressive. There is no proved explanation for the late appearance of symptoms. Basilar impression, as is evident from the case reports which follow, is frequently a fatal condition.

The symptoms of basilar impression are so variable, and may so closely simulate other neurological lesions, that the diagnosis will rarely be made during life except through roentgen examination of the region of the deformity. The first diagnosis of basilar impression in life was made by Schüller in 1904 (1); Fiszhaut and Zabokrzycki (35) claim to have made the sixth, in 1936.

The clinical characteristics of basilar impression are of two types: skeletal and neurological. The skeletal sign is a short neck, with the head shifted downward between the shoulders and tilted backward. Movements of the head on the neck are restricted. Neurological signs are irritation and paralysis of cervical nerves and spinal cord tracts due to compression at or near the foramen magnum; irritation and paralysis of cranial nerves in the posterior fossa; compression of the medulla oblongata by the odontoid process, which projects through the foramen magnum into the posterior cranial fossa; cerebellar disturbances due to compression of the cerebellum in a shallow posterior cranial fossa; finally, an increase in intracranial pressure.

Some of the cases reported as basilar impression, and others described under other titles but which seem to be basilar impression from the material given in the report, are briefly presented below. It is not intended that this should be a complete list of all reported cases of basilar impression, but it is rather an attempt to give some indication of the multiple titles under which they are reported, to demonstrate the numerous clinical syndromes resulting from this anomaly of develop-

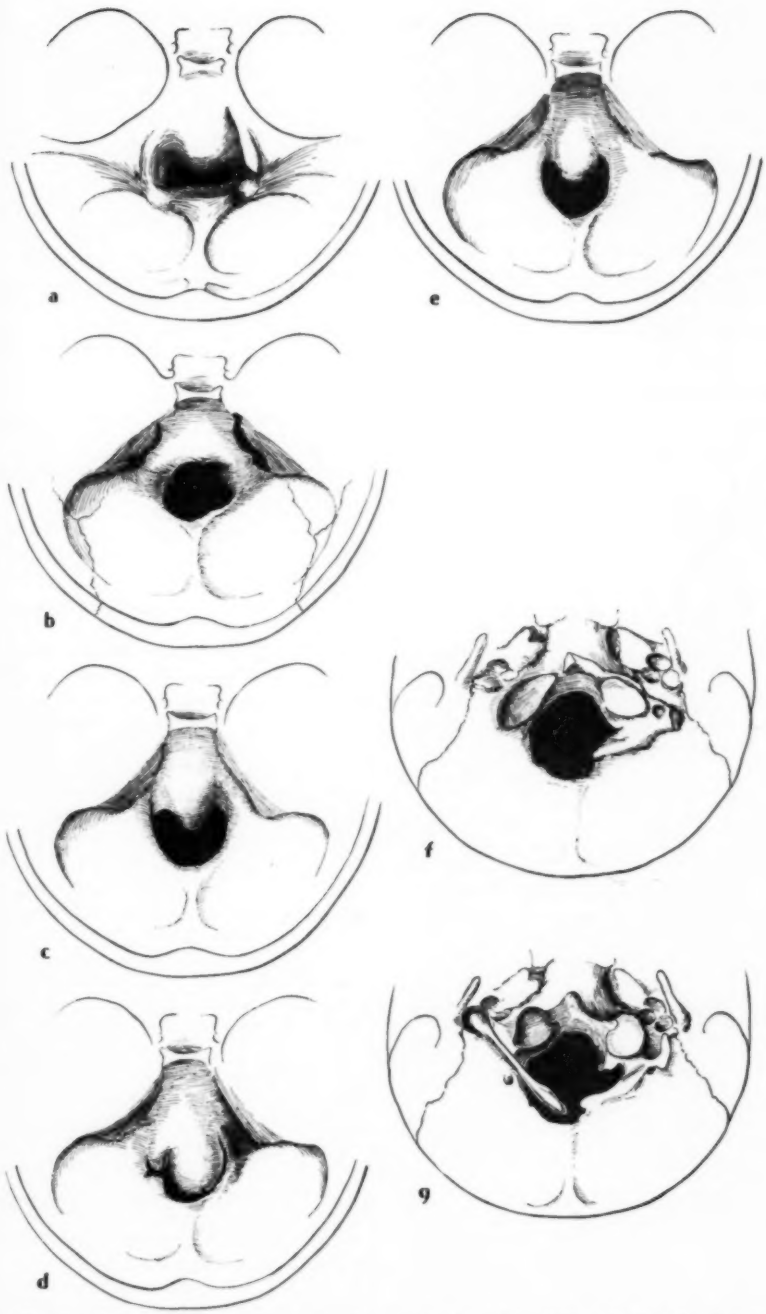

Fig. 3. The foramen magnum: drawings made from illustrations in the literature. Illustrations *a* to *e*, inclusive, are of the foramen magnum as seen from above. In *b* the dura has been removed. The sources of the illustrations are as follows: *a*. Homén. *b*. Schüller. *c*. Dejerine. *d*. Meier. *e*. Apert, Odinet, and Lang. *f*. Green (museum specimen of unilateral assimilation of the atlas). *g*. Rau and Sivasubrahmaniam (museum specimen; assimilation of the atlas and elevation of the anterior margin of the foramen magnum, basilar impression).

ment, and to illustrate the erroneous diagnoses which are apt to be made. Since basilar impression so frequently simulates syringomyelia, multiple sclerosis, or tumors of the posterior cranial fossa, many if not most cases have no doubt been entirely overlooked and filed away under these diagnoses. Two of our cases reported here were discovered by reviewing the old roentgenograms of cases previously diagnosed syringomyelia and multiple sclerosis in the University of Minnesota Hospitals. These patients were then recalled for further clinical and roentgenological study.

CASE REPORTS FROM THE LITERATURE

1. SCHIFFNER (20), 1878: Discussing the skull base in atlas assimilation Schiffner reported the case of a middle-aged woman who died of carcinoma of the stomach. Postmortem examination showed a deformity about the foramen magnum including the clivus, atlas assimilation, and a fusion of the 2d and 3d cervical vertebrae.

2. GRAWITZ (9), 1880: Grawitz reported as basilar impression a case with few or no symptoms except abnormal position and deformity of the head. The patient was deaf in the left ear. Death was due to tuberculosis. Postmortem examination showed a fusion of the 2d, 3d, and 4th cervical vertebrae, assimilation of the atlas, and a wide clivus.

3. HOMÉN (7), 1901: Homén reported as a rachitic deformity and hyperostosis of the skull base the case of a 22-year-old male who suffered headaches of increasing intensity when 18 years old and one year later began to have fainting spells. When 20 years old he began to have double vision, difficulty in swallowing, and generalized weakness, which progressed to complete disability in the course of a year. His gait was unsteady and he walked with a wide base. When he was admitted to the hospital, three weeks before death, his speech was stiff and slow and examination revealed nystagmus and hyperreflexia with ankle clonus. Death was due to pneumonia. The postmortem appearance of the posterior cranial fossa as seen from above is reproduced in Figure 3*a*.

4 and 5. SCHÜLLER (1), 1911: Two cases of basilar impression are reported by Schüller. A 21-year-old woman complained of occipital headache and immobility of the head, of one week's duration. Later difficulty of speech and swallowing developed. Examination showed limitation of head movements, the occiput being held in apposition to the neck. There were also paralysis and atrophy of the right side of the tongue. Diagnosis was made from a lateral roentgenogram of the skull and cervical spine.

Schüller's second patient was a 16-year-old male with spastic paresis of all four extremities and dissociation of sensory loss. A diagnosis of syringomyelia was made. Postmortem examination showed elevation of the skull base, assimilation of the atlas; only an asymmetrical small rudiment of the transverse process of the atlas was present. The posterior fossa of the skull as it appeared from above is reproduced in Figure 3*b*.

6. DEJERINE (36), 1926: A condition reported as defective development of the base of the occipital bone was found in a 30-year-old woman who died after twenty days of dyspnea and tachycardia. A left hemiparesis of the soft palate became bilateral three days before death. Fig. 3*c* is a reproduction of the region of the foramen magnum drawn from a photograph in Dejerine's report.

7. APERT, ODINET, AND LANG (37), 1928: These writers reported as inferior bulbar myasthenic syndrome the case of a girl 15 years old complaining of extreme asthenia and fatigue of four months' duration. She also complained of headache and limitation of flexion and extension of the head on the neck. Death occurred a few days after admission to the hospital, probably from respiratory failure. The clivus is said to have been normal in form and size, but a well developed atlas was fused with the occipital bone.

It is true that this case should not be included as a typical case of basilar impression, but it is a congenital lesion of the same type, even though it did not involve the basilar portion of the occipital bone. It is interesting to note that Apert reported this case three times, each time having a different opinion concerning the nature of the lesion (37, 38, 39). A drawing of the region of the foramen magnum reproduced from a photograph included in the first two reports is shown in Figure 3*e*.

8. MEIER (2), 1928: Meier reported a high-grade bony obstruction of the foramen magnum by a displaced and deformed odontoid process which produced syringomyelia-like symptoms in a 79-year-old woman. When 68 years old she was seen for limited movements of the atlanto-occipital joint, occipital pain, and joint changes simulating syringomyelia. Examination revealed extensive muscle atrophy of the upper extremities, increased quadriceps reflexes, absence of abdominal reflexes, a positive Babinski sign, and lateral nystagmus. The symptoms were progressive up to the time of death, which was, however, not due to this condition. A drawing of the photographed postmortem specimen of the posterior cranial fossa is reproduced in Figure 3*d*. Another photograph of a mid-sagittal section of the region of the foramen magnum showed an elevation of the basilar portion of the occipital bone. There is no indication that the atlanto-occipital joint was examined.

9. BÉZI (6), 1931: Bézi reported as assimilation of the atlas and compression of the medulla the case of a 33-year-old male who gave a history of having for two years an abnormal head position,

limitation of motion of the head on the cervical spine, headache, and pain in the neck. Approximately two weeks before death he began to vomit and to exhibit a staggering gait. Death was due to medullary compression. Autopsy demonstrated a broad flat clivus, its angle with the horizontal plane being decreased. The atlas was fused with the occipital bone. The odontoid process projected up through the anterior part of the foramen magnum.

10. ADAM-FALKIEWICZOWA AND NOWICKI (8), 1931: This case, reported as an unusual deformity of the basilar portion of the occipital bone which clinically appeared to be bilateral cerebellopontine angle tumor, was observed in a 45-year-old man who was found postmortem to have a gibbus-like deformity of the clivus. Pressure by this deformity on the medulla and neighboring structures produced the symptoms.

11. GUILLAIN AND MOLLARET (19), 1931: Guillain and Mollaret reported as Klippel-Feil's syndrome with spasmodic quadriplegia the case of a 33-year-old man with a thirteen-year history of progressive spastic paralysis, abnormal position, and limited movements of the head. Diagnosis of Klippel-Feil's syndrome was made from roentgenograms which showed a fusion of the upper cervical vertebrae. It is quite possible that this is not a case of basilar impression, but the authors' description and the reproduced films indicate that it is another unrecognized example.

12. BODECHTEL AND GUIZETTI (5), 1932: These writers reported as pseudo-tumor cerebri a case also reported by Sinz (3), as death due to underdevelopment of the occipital and sphenoid bones together with synostosis of the atlas with the skull. The patient was a 27-year-old man who at 12 years of age developed a characteristic head position and five weeks before death had an onset of severe headache, vomiting, drowsiness, and syncope. Examination a few days before he died revealed limitation of head movement, lordotic cervical spine, nasal speech, horizontal nystagmus, and a tendency to fall to the left. Death occurred in an epileptiform seizure. The clinical diagnosis was cerebellar tumor or encephalitis. Autopsy showed a lordotic upper cervical spine, the clivus pushed up, and a horseshoe-shaped elevation about the foramen magnum. The odontoid process projected through the foramen magnum and there was atlas assimilation.

13. KECHT (4), 1932: Kecht reported as basilar impression the case of a 57-year-old woman who had been vomiting for eight months; for three months she had an unsteady gait, mental deterioration, and urinary retention. Just before death a paresis of all extremities developed. Roentgenograms showed a typical basilar impression. Respiratory failure was the cause of death. Postmortem examination demonstrated a flat clivus with a projection of the anterior and lateral margins of the foramen magnum into the cranial cavity; the whole posterior cranial fossa was small. There was a high-grade assimilation of the atlas.

14. POMMÉ, CASSOU, AND TRICAULT (18), 1932: This case, reported as congenital malformation of the cervical spine with bulbar symptoms, occurred in a 40-year-old man with a short neck and limited head movements, with three-year history of bulbar symptoms. He had nystagmus, Horner's syndrome, paralysis, and sensory impairment of the right side of the pharynx, atrophy of the right side of the tongue, analgesia of the left side of the body.

This is another case about which there may be some question, but from the information given and the roentgenograms it seems to be an example of unrecognized basilar impression.

15–18. EBENIUS (40), 1934: Ebenius reported four cases as basilar impression. The sex as given here is taken from Alessi (33). A girl 15 years old gave a two and a half-year history of progressively increasing pain in the occipital region, disturbed equilibrium, and weakness of the lower limbs. Examination showed a hydrocephalic head, choked discs, nystagmus, positive Romberg sign, and spastic gait. In roentgenograms the posterior fossa of the skull was elongated and its floor elevated around the foramen magnum, the margins of which were directed upward. The atlas and axis were deformed. At operation the pineal region was exposed but death occurred four weeks later. The autopsy diagnosis was basilar impression with deformity of the cerebellum and medulla oblongata.

A 21-year-old male had impaired vision of three years' duration and headache of a year's duration. Examination revealed choked discs, nystagmus, and unsteady gait. Roentgenograms showed the posterior fossa of the skull flattened and its floor attenuated. The basal angle was increased and the atlas and axis were deformed. A diagnosis of basilar impression was made on the basis of these films. Cerebellar decompression led to some improvement.

Ebenius' third patient was a 59-year-old woman giving a three-year history of headache and difficulty in swallowing. She had a short neck, convergent strabismus, nystagmus, unilateral pharyngeal paresis, unsteady gait, and a positive Romberg sign. Roentgenograms showed the attenuated floor of the posterior fossa elevated about the foramen magnum. The atlas and odontoid process were elevated to the level of the pyramids. The atlas and axis were deformed. The basal angle was increased. The diagnosis was basilar impression. Suboccipital decompression was followed by slight subjective improvement.

The fourth patient, a 46-year-old male, gave a two-year history of disturbance of equilibrium and diplopia. Examination showed nystagmus, unsteady gait, and a positive Romberg sign. Roentgen study revealed attenuation of the floor of the posterior cranial fossa and deformity of the clivus and atlas. The diagnosis was basilar impression. Suboccipital decompression and excision of the

arch of the atlas were followed by subjective improvement.

19. STENVERS (14), 1936: Stenvers reported as basilar impression the case of a 17-year-old girl whose symptoms were of eleven months' duration. The first symptom was headache; one month later she noticed loss of vision, then vomiting and disturbances in consciousness. Three months after the onset she began to have double vision. Examination revealed exophthalmos, an almost complete left homonymous hemianopsia, an old neuroretinitis with visual acuity 1/30 in the left and 1/60 in the right eye, a nystagmus on looking to the left, decreased corneal reflex on the right side, partial deafness of right ear, and paralysis of the right hypoglossal nerve. Before operation only signs of pressure about the sella turcica were noted roentgenologically, but when the films were reviewed postmortem typical findings of basilar impression were seen.

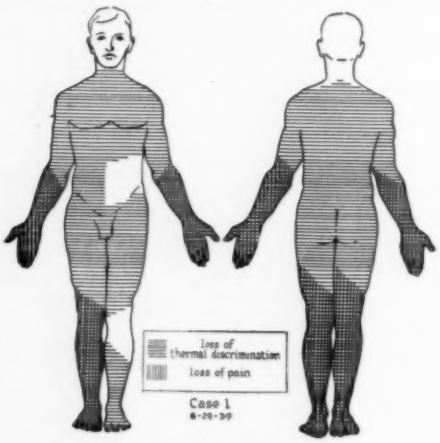

Fig. 4. Case 1: Sensory changes.

A transnasal operation for pituitary tumor was performed and followed by immediate death. Postmortem the skull base appeared as though it had been forced down over the cervical spine with elevation of the basilar portion of the occipital bone and the petrous pyramids. The medulla was compressed from below, chiefly on the right side. There was hydrocephalus.

20. FISZHAUT AND ZABOKRZYCKI (35), 1938: This case, reported as basilar impression, occurred in a 56-year-old male with asynergia of the trunk, a tendency to fall backward, and a wide base in walking. His symptoms were of sixteen years' duration. Roentgenograms showed the classical findings of basilar impression: increased anterior-posterior diameter of skull, horizontal clivus, increased angle of the base of the skull, and protrusion of the basilar and condylar portions of the occipital bone into the cranial cavity. The atlas and axis were deformed.

21. BAU-PRUSSAK AND FISZHAUT-ZELDOWICZ (34), 1938: A case of basilar impression is reported in a boy of 15 years, who from an early age had severe headaches and vomiting. Weakness of all extremities developed. The neck was short; the head was slightly rotated to the right, with limitation of head movements. There was a spasmodic tetraparesis. Roentgenograms showed hypoplasia of the atlas and axis with subluxation and rotation of the atlas, and upward displacement of the odontoid process.

22–25. CHAMBERLAIN (11), 1939: Chamberlain reported 4 cases as basilar impression. A 20-year-old male for five years had a torticollis, and for one year tremor of the hands, sphincter disturbance, anesthesia of certain skin areas and weakness of all extremities. Examination showed some motor impairment of all extremities, hyperreflexia in lower extremities, a positive Babinski sign, and disturbance of sensation. The roentgen findings were typical of basilar impression (earlier diagnosis had been syringomyelia). Operation consisted in occipital craniectomy and laminectomy of the upper 3 cervical vertebrae. The atlas was found to be highly assimilated. There was extensive improvement after operation and two years later the patient was under no significant handicap.

The second of Chamberlain's patients was a 28-year-old woman complaining of weakness in her legs and a drawing pain in the abdomen one year in duration. Examination showed nystagmus in all directions, absence of corneal reflexes, hypalgesia over the right trigeminal nerve distribution, paresis of the right 7th nerve, a positive Romberg sign, cerebellar dyssynergia and motor impairment in all extremities, hyperreflexia, absence of abdominal reflexes, a bilateral Babinski sign, and sensory disturbances. Characteristic deformities of basilar impression were demonstrable roentgenologically.

Operation—occipital craniectomy and laminectomy of the upper three cervical vertebrae without opening the dura—was followed by improvement for ten months, then recurrence and death one year after the operation. Postmortem examination demonstrated a constricting and compressing calcified mass in the dura about the foramen magnum, which was interpreted as the cause of death.

The third patient was a 43-year-old woman who had recent aphasia, vomiting, and a right hemiplegia. She was found to have syphilis and the symptoms and findings were all considered to be due to thrombosis of the middle cerebral artery. Roentgenologic examination, however, demonstrated the typical deformity of basilar impression, presumably without production of symptoms.

Chamberlain's fourth case was that of a 31-year-old man, who gave a six-year history of weakness and inability to distinguish hot and cold in the left arm and hand. Later all extremities became weak and for 6 months there was absence of sweating on the right side. Examination showed a Horner's syndrome on the right, muscle atrophy especially of the shoulder girdle muscles, diminished reflexes

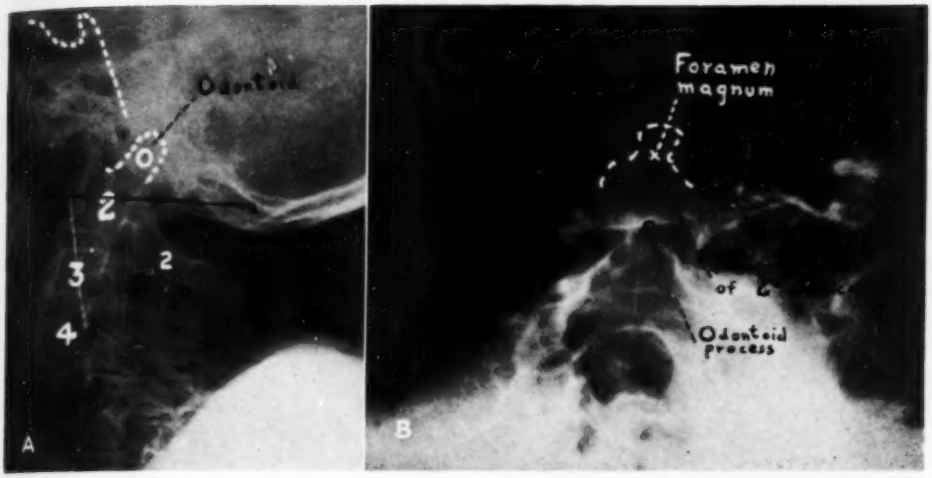

Fig. 5. Case 1: In A is seen the palato-occipital line described by Chamberlain, connecting the posterior part of the hard palate with the posterior part of the foramen magnum. The odontoid process is well above this line, suggesting a platybasia. There is no anterior or posterior arch distinguishable for the first cervical vertebra. There is a lordosis of the cervical spine. B. Deformed outline of the posterior part of the small foramen magnum demonstrated by the occipital view.

in the upper extremities and hyperreflexia in the lower extremities, loss of pain sense in certain segments, and decreased pain sensitivity in others. Roentgenograms revealed basilar impression, but the patient died before the condition was recognized in the films.

26. ALESSI (33), 1939: Alessi reported as basilar impression the case of a 26-year-old male who from infancy had a short neck. He gave a four-year history of disturbance in temperature sensibility and of weakness in the left side. Two years later all extremities were involved and he had ataxia in his arms. For eight months he had urinary incontinence. Examination showed a short neck, ataxia and spasticity in all extremities, horizontal nystagmus, positive Romberg sign with a tendency to fall to the left, extensive disturbances of all types of sensation, in some areas dissociation of sensory loss, increased reflexes in the upper and decreased in the lower extremities. Roentgen findings were lordosis of the cervical spine, elevation of the clivus, absence of the anterior arch of the atlas, and displacement of the odontoid process into the cranial cavity.

REPORT OF THREE CASES OBSERVED

Three cases of basilar impression have been observed since we became familiar with this condition; two of them were found by recalling patients whose records on review suggested possible platybasia.

CASE 1 (Hospital No. 624,501): A male, 32 years of age, noticed a flexion contracture of the fingers and weakness and atrophy of muscles in his left hand during 1928, when he was 21 years old. One year later similar changes appeared in his right hand, and at the same time he experienced disturbance of temperature sensibility of both hands. In 1932 weakness and numbness of the lower extremities developed; also a disturbance of speech associated with drooling from the left angle of the mouth.

Physical findings when the patient was first seen in the outpatient department, in February 1934, were kyphosis of the thoracic spine, a short neck with the head tilted backward, scars following painless burns on both hands. No cranial nerve changes were noted. The Romberg test was positive. Babinski's sign was present on both sides. There was an increase in all deep reflexes and decrease in pain sensation over all extremities. Laboratory tests were within normal limits. A diagnosis of probable syringomyelia of the upper cervical region was made.

The patient was called for re-examination in August 1939. The interval history was one of very slow progression of the previous symptoms. Examination now revealed an absence of convergence of the eyes and weakness but not paralysis of the left vocal cord. The patient walked with a wide base. The Romberg sign was present. There was atrophy of the muscles of the forearms and hands. A notable difference from the previous examination was that the deep reflexes in the upper extremity were now decreased or absent, the abdominal reflexes were absent, and the lower extremity deep reflexes were greatly increased, with sustained knee and ankle clonus. There was a more extensive and complete sensory loss than at the time of the previous examination (Fig. 4). There was past pointing with the right hand and a horizontal nystagmus on looking to the left.

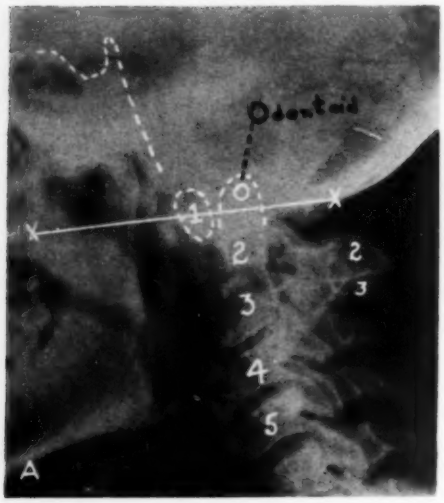

Fig. 6 A. Case 2: Part of the odontoid process is seen above the palato-occipital line. There is no posterior arch for the first cervical vertebra but the anterior arch is present, labelled 1. The second and third cervical vertebrae are fused.

Roentgenograms (Fig. 5) demonstrated definite abnormalities in the region of the foramen magnum. The foramen was small and irregular in contour. The anterior and posterior arches of the atlas were not visible, being fused with the occipital bone. The transverse processes were faintly visible. The atlanto-occipital joint was not present, and the odontoid process projected up through the foramen magnum much higher and more posterior than normal. The basal angle was 146°. There was no definite evidence of elevation or rotation of the medial ends of the petrous pyramids. There was a lordosis of the cervical spine.

Diagnosis: Basilar impression.

Operation, September 1, 1939: A suboccipital decompression was done, the posterior arch of a highly assimilated atlas and the laminae of the second and third cervical vertebrae were removed. The dura was opened throughout the vertical extent of this decompression. The foramen magnum was small but there was adequate room for the medulla to project through it without compression. Recovery was uneventful and one year later there has been no change in the condition except slight subjective improvement.[3]

CASE 2 (Hospital No. 680,295): This man, 41 years old, seen in April 1939, gave a two-year history of low back pain radiating into the right lower extremity. One month after the onset of pain a weakness of the right lower extremity developed and soon thereafter of the left lower extremity as well. Six months after the onset of symptoms there occurred pain in the neck, aggravated by rotation or flexion. One year after the onset of symptoms weakness appeared in the upper extremities and the patient complained of pains in his back, radiating to the neck, so severe that he was completely disabled.

There were no abnormal findings in the cranial nerves. Babinski's sign was positive on the right side. The deep reflexes in all extremities were increased. There was bilateral ankle clonus. A general weakness was observed in all movements of the extremities. Results of laboratory tests were within normal limits.

Roentgenograms (Fig. 6) demonstrated fusion of the laminae and bodies of the second and third cervical vertebrae, but the true extent of the anomalous changes about the foramen magnum were not realized until the patient was recalled for examination in September 1939. In addition to the above-mentioned anomalous development it was then noted that the foramen magnum was so small that it could not be conclusively demonstrated either in the anteroposterior or postero-anterior projections recommended by Chamberlain (11). The odontoid process projected upward through the foramen magnum. The posterior arch of the atlas could not be made out and the anterior arch was very indistinct. The medial ends of the petrous pyramids appeared to be slightly elevated. Laminagraphs showed quite conclusively a fusion of the atlanto-occipital joints, and a foramen for the vertebral artery was seen in or above the fused transverse process of the atlas. The basal angle was difficult to determine accurately but measured approximately 130°. The squamous and condylar parts of the occipital bone were displaced upward.

Diagnosis: Lateral sclerosis was the diagnosis until these typical roentgenologic findings of basilar impression were recognized.

Operation for basilar impression was advised but refused. Observation over a period of approximately one year has demonstrated slight progression of the neurological lesion.

CASE 3. This is the case of a man who was recently injured in an automobile accident and since that time has had pain bilaterally over the occipital region. We have not had the opportunity to examine this man, but Dr. J. C. Hultkrans has done so and reports no abnormal neurological findings.

In the roentgenograms (Fig. 7) the posterior arch of the first cervical vertebra cannot be identified and the spinous process of the second cervical vertebra is seen immediately adjacent to the occipital bone. The anterior arch and the transverse processes of the first cervical vertebra are well developed. The atlanto-occipital joint is obliterated on one side and very poorly developed on the other side. The foramen magnum is extremely small and difficult to demonstrate conclusively. The basal angle measured 125°.

Diagnosis: Basilar impression without neurological symptoms.

[3] There was still no progression or improvement in December 1941.

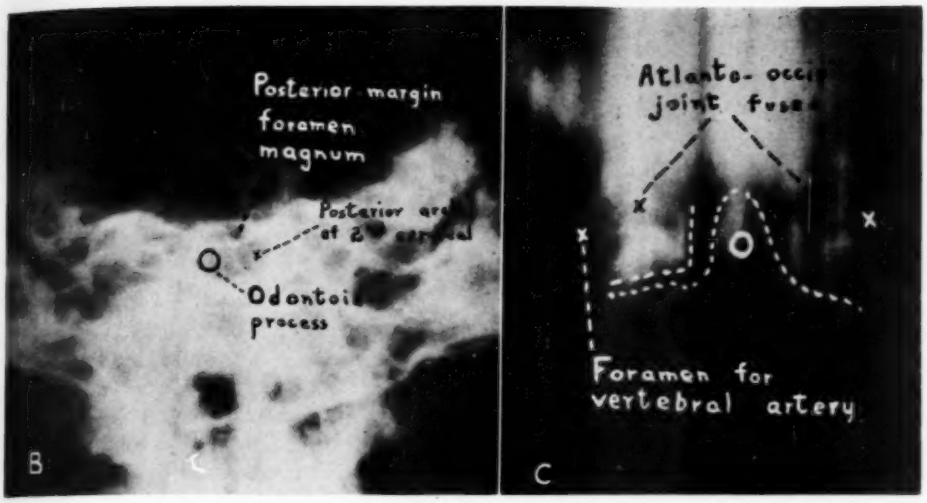

Fig. 6 B and C. Case 2: B. Occipital view. Foramen magnum is too small to demonstrate. C. Laminagraph in the anteroposterior plane showing a coronal section through the odontoid at O. The foramen for the vertebral artery and the fused atlanto-occipital joints are demonstrated.

COMMENT

Since the primary pathology in platybasia or basilar impression consists of anomalies of the occipital bone and upper cervical spine, it is quite natural to expect that the condition would be most readily recognized by means of roentgenographic examination. A lateral view of the cervical spine including the base of the skull will give sufficient information to make a diagnosis of basilar impression. We make this statement because we believe that all cases will have some degree of assimilation of the atlas in which the posterior arch will be fused with the occipital bone. Consequently in a lateral roentgenogram of the upper cervical spine there will either appear a very rudimentary posterior arch or none at all will be visible. In addition, a lateral view will demonstrate the high position of the odontoid process. Chamberlain (11) advocates drawing a line from the posterior edge of the hard palate to the posterior lip of the foramen magnum. If the odontoid process projects above this line, basilar impression may be suspected. We have observed this in our cases but find it very difficult to be certain of the above-mentioned landmarks on the roentgenograms. Elevation of the floor of the posterior fossa around the foramen magnum is not an outstanding roentgenographic finding. Changes in the basal angle are inconstant as observed in our 3 cases, in which this angle varied from 125° to 147°. Elevation and rotation of the medial ends of the petrous pyramids is also an inconspicuous roentgen finding if present at all. A decrease in size and a distortion of the shape of the foramen magnum are of constant occurrence, but seem to be extremely difficult to record conclusively on the films. We have tried the usual anteroposterior projections and also the reverse or postero-anterior view advocated by Chamberlain (11), in addition to the vertico-submental and submento-vertex views. In the normal skull the foramen magnum can be demonstrated very nicely by these projections. In cases of basilar impression the shortness of the neck and difficulty experienced in flexing the neck, together with the existing deformity of the foramen magnum, make for very unsatisfactory films of this region. We have found it possible, however, to demonstrate quite well a synostosis at the atlanto-occipital joint.

Laminagraphy was done in one of our cases and this fusion was very clearly brought out, as were the foramina in the transverse processes of the atlas for the vertebral artery.

Of the 26 cases collected from the literature and the 3 personal cases reported, 17 were in males, 11 were in females, and in one the sex was not given. The age at the time of examination varied from 15 to 70 years, averaging 34 years. In 23 cases it was possible to determine approximately the age at the onset of symptoms. This averaged 29 years. Neurological symptoms were absent in 4 and present in 25 patients, causing death in 10. Operation was performed in 8. In one instance exploration was done for tumor of the pineal gland with postoperative death; in another, exploration was done for a pituitary tumor with immediate postoperative death. Two patients had suboccipital decompression with some improvement, while 4 had suboccipital decompression and laminectomy of the upper cervical vertebrae with an excellent result in one and subjective improvement in the other 3. One of these, however, experienced a relapse and died one year after operation.

This record does not speak well for operation in the treatment of basilar impression, but too few patients have been operated upon for a fair test, only 4 having had an adequate operation. To expect regeneration of tracts in the central nervous system that have been destroyed by compression over a number of years is not warranted. One should be content if operation stops the progression of a fatal lesion. It has been said that operation is not indicated (12). The suggestion has been made that anomalies of development of the central nervous system itself are at times the cause of the neurological symptoms rather than the bony anomalies, and that decompression will therefore not give relief. This statement is not supported by postmortem examination, except possibly in the case reported by Bézi (6). In addition, it is reasonable to believe that symptoms due to anomalous development of the central nervous system would appear earlier in life, if not from the time of birth.

For the present, until the result of operation has been evaluated by a larger number of cases observed for a sufficient period to determine the effect on the progression of the lesion, all cases with neurological symptoms should be treated operatively as soon as the diagnosis is made; operation should decompress both the posterior fossa and upper cervical spine by suboccipital craniectomy and laminectomy of the upper cervical vertebrae. In one case death seems to have occurred one year after operation because a constricting band was not released by opening the dura. Chamberlain (11) has suggested that in some cases it may be necessary in addition to section the tentorium, to decompress the posterior fossa.

It is interesting to note that in our first case there was extensive muscle atrophy in the hands and forearms and loss of tendon reflexes in the upper extremities. Similar muscle atrophy of the upper extremities was noted by Meier (2). That compression of the spinal cord at the foramen magnum or upper cervical vertebral segments may produce localized muscle atrophy and loss of reflexes in the upper extremities has long been known (41–45). This anterior horn lesion is probably due to compression of the anterior spinal artery which supplies this part of the cord.

Otherwise our cases were in no way remarkably different than others reported in the literature. Case 1 was diagnosed as syringomyelia and passed under this diagnosis on repeated visits to the Outpatient Clinic over a four-year period. Case 2 was diagnosed as lateral sclerosis a few months before the proper diagnosis was established.

SUMMARY

Anomalies about the foramen magnum and upper cervical spine are frequent. Minor anomalies are especially frequent but basilar impression, which is a combination of severe grade of anomalous de-

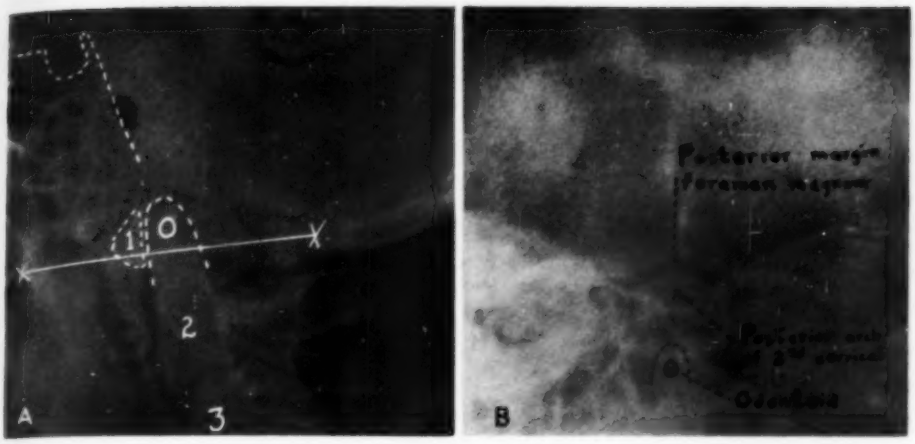

Fig. 7. Case 3: In A the odontoid process (O) is partly above the palato-occipital line. There is no posterior arch for the first cervical vertebra. The anterior arch of the first cervical vertebra is shown at 1. B. The foramen magnum is not as small as in Cases 1 and 2, since the odontoid process is observed to lie a greater distance from its posterior margin.

velopment of the occipital bone and upper cervical vertebrae, is a rare lesion. In the typical specimen the cervical spine appears to have been pushed up into the base of the skull. The margins of the foramen magnum are pushed upward and it is small and irregular in outline. The basilar portion of the occipital bone is elevated, which in turn decreases the downward slope of the clivus, and at the same time the trough of the clivus becomes broad and flat. The medial ends of the petrous portions of the temporal bones are elevated and the floor of the posterior fossa is thin. The atlas is more or less rudimentary, fused to the occipital bone.

Neurological symptoms may or may not be present in basilar impression. As a rule, they do not appear until after adolescence but they are progressive, and the lesion is frequently fatal.

The symptoms and physical findings are extremely variable. These come under the headings (1) skeletal—a short neck and an abnormal head position with limitation of head movements—and (2) neurological symptoms—cranial nerve, cervical nerve and spinal cord tract irritation or paralysis, symptoms due to compression of the cerebellum and medulla oblongata, and increased intracranial pressure.

Roentgenograms of the base of the skull and cervical spine will demonstrate all of the gross bony anatomical variations present. The most readily observed roentgen findings are the absence of the posterior arch of the first cervical vertebra and the high and somewhat posterior position of the odontoid process. These changes are easily seen in a lateral view of the cervical spine and base of the skull. For further verification of the diagnosis attempts should be made to demonstrate the foramen magnum and the fusion of the atlanto-occipital joints.

Twenty-six cases from the literature are reviewed and three additional cases are reported.

When neurological symptoms are present, a suboccipital craniotomy and laminectomy of the upper cervical vertebrae should be performed. Cases having had such an operation are as yet too few to enable one to evaluate the results. If it is found that operation will prevent progression of a condition which is frequently fatal, even if extensive restoration of lost function is not obtained, surgery will replace the hopeless attitude that basilar impression is an interesting lesion for which nothing can be done.

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REFERENCES

1. SCHÜLLER, A.: Zur Röntgen-Diagnose der basalen Impression des Schädels. Wien. med. Wchnschr. **61:** 2593, 1911.

2. MEIER, E. J.: Ein Fall von hochgradiger knöcherner Obturation des Foramen occipitale magnum durch einen dislozierten u. deformierten Epistropheuszahn mit syringomyelie-ähnlichem klinischem Bild. Schweiz Arch. f. Neurol. u. Psychiat. **24:** 303, 1929.

3. SINZ, P.: Unterentwicklung des Hinterhaupt- und Keilbein-Körpers mit gleichzeitiger knöcherner Verbindung zwischen Atlas und Schädel als Todesursache. Virchows Arch. f. path. Anat. **287:** 641, 1933.

4. KECHT, B.: Zur Kenntnis der Klinik eines Falles von basilarer Impression des Schädels. Ztschr. f. d. ges. Neurol. u. Psychiat. **141:** 132, 1932.

5. BODECHTEL, G., AND GUIZETTI, H. U.: Pseudotumor cerebri bedingt durch eine röntgenologische fassbare Anomalie des Hinterhauptloches mit Verlagerung der beiden oberen Halswirbel. Ztschr. f. d. ges. Neurol. u. Psychiat. **143:** 470, 1933.

6. BÉZI, I.: Assimilation of the Atlas and Compression of the Medulla. Arch. Path. **12:** 333, 1931.

7. HOMÉN, E. A.: Zur Kenntniss der rhachitischen (?) Deformationen der Schädelbasis und der basalen Schädelhyperostosen. Deutsche Ztschr. f. Nervenh. **20:** 3, 1901.

8. ADAM-FALKIEWICZOWA, S., AND NOWICKI, W.: Eine ungewöhnliche Entwicklungsstörung des occipitale Basilare mit dem klinischen Bilde eines doppelseitigen Kleinhirnbrückenwinkeltumors. Zentralbl. f. d. ges. Neurol. u. Psychiat. **61:** 472, 1931.

9. GRAWITZ, P.: Beiträge zur Lehre von der basilaren Impression des Schädels. Virchow's Archiv. f. path. Anat. **80:** 449, 1880.

10. WAKELEY, C. P. G., AND ORLEY, A.: A Textbook of Neuro-Radiology. London, Baillière, Tindall and Cox, 1938.

11. CHAMBERLAIN, W. E.: Basilar Impression (Platybasia). Yale J. Biol. & Med. **11:** 487, 1939.

12. LIST, C. F.: Neurological Syndromes Associated with Developmental Anomalies of the Occiput, Atlas, and Axis. Univ. Hosp. Bull., Ann Arbor, Mich. **5:** 57, 1939.

13. SCHÜLLER, A.: Diagnosis of Basilar Impression. Radiology **34:** 214, 1940.

14. STENVERS, H.: Basale Impression. In Bumke and Foerster: Handbuch der Neurologie, Berlin, Julius Springer, 1936. Vol. 7, p. 174.

15. RUSSELL, F.: Studies in Cranial Variation. Am. Natur. **34:** 737, 1900.

16 LE DOUBLE: Quoted by Bystrow (17).

17. BYSTROW, A.: Assimilation des Atlas und Manifestation des Proatlas. Ztschr. f. d. ges. Anat. (Abt. 1) **95:** 210, 1931.

18. POMMÉ, B., CASSOU, R., AND TRICAULT, G.: Au sujet d'un syndrome bulbaire d'apparition récente chez un sujet porteur de malformations osseuses cervicales vraisemblablement congénitales. Rev. neurol. **1:** 264, 1932.

19. GUILLAIN, G., AND MOLLARET, P.: Syndrome de Klippel-Feil avec quadriplégie spasmodique. Rev. neurol. **1:** 436, 1931.

20. SCHIFFNER, C. T.: Ueber die Architectur des Schädelgrundes in der Norm und bei Assimilation des Atlas. Virchow's Arch. f. Path. Anat. **74:** 320, 1878.

21. KOLLMAN, J.: Variaten am Os Occipitale besonders in der Umgebung des Foramen Occipitale Magnum. Verhandl. der. Anat. Gesellsch. **19:** 231, 1905.

22. BOLK, L.: Zur Frage der Assimilation des Atlas am Schädel beim Menschen. Anat. Anz. **28:** 497, 1906.

23. SCHUMACHER, S.: Eine Beitrag zur Frage der Manifestation des Occipital Wirbels. Anat. Anz. **31:** 145, 1907.

24. BYSTROW, A. P.: Morphologische Untersuchungen über die Occipitalregion und die ersten Halswirbel der Säugetiere und des Menschen; die Assimilation des Atlas und deren phylogenetische Bedeutung. Ztschr. f. Anat. u. Entwckingsgesch. **102:** 307, 1933.

25. RAU, R. K., AND SIVASUBRAHMANIAM, D.: Anomalous Atlanto-Occiput. J. Anat. **67:** 622, 1933.

26. LATARJET, M.: Un cas d' occipitalisation de l'atlas. Ann. d'anat. path. **13:** 749, 1936.

27. MOTWANI, R. C.: Some Rare Abnormalities of Bones in Anatomy Museum of Grant Medical College, Bombay (Partial Lateral Fusion of Atlas with Occipital Bone). J. Anat. **71:** 131, 1936.

28. LANIER, R. R., JR.: An Anomalous Cervico-Occipital Skeleton in Man. Anat. Rec. **73:** 189, 1939.

29. MECKEL, J.: Ueber einige Abnormitäten der Knocken. Deutsches Arch. f. d. Physiol. **1:** 641, 1815.

30. SWJETSCHNIKOW: Ueber die Assimilation des Atlas und die Manifestation des Occipitalwirbels beim Menschen. Arch. f. Anat. u. Ent., 1906, p. 155.

31. RENANDER, A.: Anomalies Roentgenologically Observed of the Cranio-Vertebral Region. Acta. radiol. **10:** 502, 1929.

32. FRIEDLOWSKY, A.: Weiner med. Lehrbüchen. **16:** 240, 1868. Quoted by Swjetschnikow (30).

33. ALESSI, D.: Contributo allo studio delle sindromi neurologiche da impressione basilare dello scheletro. Riv. di neurol. **12:** 218, 1939.

34. BAU-PRUSSAK, S., AND FISZHAUT-ZELDOWICZ L.: Deux cas d'anomalie de développement de la colonne cervicale avec syndrome syringomyélique dans l'un tétraparésie et imporession basilare du crane dans l'autre. Rev. neurol. **70:** 385, 1938.

35. FISZHAUT, L., AND ZABOKRZYCKI, J.: Impression basilare cranienne avec tableau dominant d'atrophie cérébelleuse. Rev. neurol. **70:** 354, 1938.

36. DEJERINE: Dystrophie osseuse par aplasie de la substance spongieuse du corps basilaire de l'occipital. Bull. Acad. de méd., Paris **96:** 21, 1926.

37. APERT, E., ODINET, AND LANG: Syndrome de myasthénie bulbaire inférieure. Bull. et. mém Soc. méd. de hôp. de Paris **52:** 42, 1928.

38. GRISEL, P., AND APERT, E.: La synostose occipito-atloïdienne congénitale. Presse méd. **41:** 397, 1933.

39. APERT, E.: Synostose occipito-atloïdienne congénitale ayant entraîné la mort à quinze ans per compression du bulbe. Bull. et. mém. Soc. méd. de hôp de Paris **52:** 1344, 1936.

40. EBENIUS, B.: Roentgen Appearance in Four Cases of Basilar Impression. Acta. radiol. **15:** 652, 1934.

41. OPPENHEIM, H.: Weitere Beiträge zur Diagnose und Differentialdiagnose des Tumor medullae spinalis. Monatschr. f. Psychiat. u. Neurol. **33:** 451, 1913.

42. SODERBERGH, G.: Einige Bemerkungen über die Lokaldiagnose von Ruckenmarksgeschwülsten. Berl. klin. Wchenschr. **51:** 242, 1914.

43. ELSBERG, C. A.: Tumors of the Spinal Cord. New York, Paul B. Hoeber, Inc., 1925, p. 299.

44. SYMONDS, C. P., MEADOWS, S. P., AND TAYLOR, J.: Compression of the Spinal Cord in the Neighborhood of the Foramen Magnum. Brain **60:** 52, 1937.

45. GRINKER, R. R.: Neurology. Baltimore, Charles C. Thomas, 1937, p. 239.

46. GREEN, H L.: An Unusual Case of Atlanto-Occipital Fusion. J. Anat. **65:** 140, 1930–31.

Influence of a Single Dose of Commonly Used Laxatives on Gastro-Intestinal Motility: A Comparative Study[1]

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IN THE ROENTGEN examination of the abdomen or lower spine it is important that the intestinal tract be rid of its contents and gas in order that proper visualization may be obtained. To accomplish this, the patient is usually advised to take a laxative. This study was undertaken to compare the action of the following laxatives on gastro-intestinal motility: cascara, licorice powder, magnesium citrate, magnesium sulphate, and castor oil. Fifteen apparently healthy young persons volunteered for this study. Each was examined with the usual water barium meal and the motility of the gastro-intestinal tract was noted. Films were made immediately after the ingestion of the meal and at intervals of one hour, three hours, four hours, six hours, eight hours, twenty-four hours, and forty-eight hours. The subjects were then divided into groups of three, and each group was again examined within a week with a similar barium mixture but this time one of the laxatives was given with the meal. Whenever it was possible the entire bulk of the laxative barium meal did not exceed the amount of the control meal.

We are cognizant of the fact that usually these laxatives are not taken with a meal but some time later, when the stomach and proximal small intestines are partly or completely empty. This, of course, might make some difference in the observations, but inasmuch as we were desirous of investigating the alteration in motility through these structures also, it was deemed best to give the laxative at the time of the barium meal.

In discussing our observations it may be well to review briefly the physiologic action of the drug used and compare with our findings.

[1] From the Departments of Radiology of the Jewish, Northeastern, and Northern Liberties Hospitals. Accepted for publication in June, 1941.

CASCARA

Physiologic Action: Cascara belongs to the anthraquinone group of cathartics. In the alkaline intestines these cathartics are oxidized, yielding various oxymethylanthraquinones which produce the cathartic action. The most common of these substances are emodin and chrysophanic acid.

Cascara increases peristalsis of both the small and large intestines but chiefly of the colon. The cathartic effect appears in from seven to twelve hours and the stools are soft but not liquid.

Observations: In this study, two drams of the fluid extract were administered in a water barium mixture. In both the control and laxative cases, the opaque meal began to leave the stomach immediately after its ingestion, but the rapidity of evacuation was slightly more marked in the laxative cases.

At the one-hour period we noted almost a total absence of the laxative-laden meal in the proximal jejunal coils, as if this opaque meal had rushed through these small intestinal loops. This meal moved more rapidly through the small intestines, as a result of which the appearance presented is that of a patchy and irregular distribution instead of a rather uniform stream.

At the three-hour period there was no difference in the amount of gastric emptying. There was a slight increase in small intestinal motility, but the marked and sharp increase through the proximal small intestines noted at the one-hour study had slowed up and now approximated closely the motility of the control.

At the four-hour period we noted very

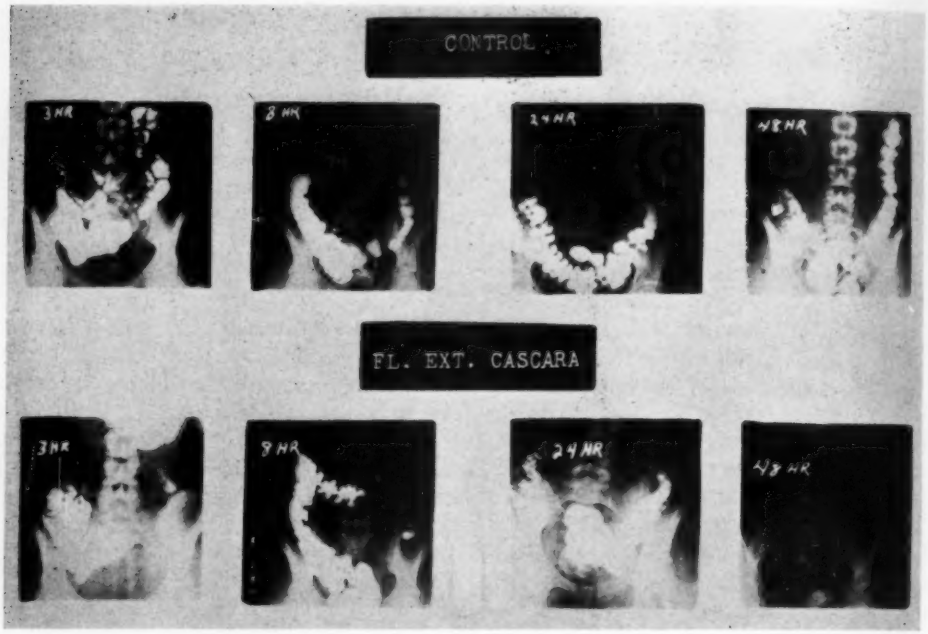

Fig. 1. Effect of Cascara on gastro-intestinal motility.

little difference in the degree of gastric and small intestinal motility with or without the ingestion of the drug. At this time the jejunum held the meal well. However, when the meal reached the colon it passed onward much more rapidly when mixed with the laxative.

At the six-hour period the motility of the colon and small intestines and the distribution of the opaque meal were about the same as in the control, but there was a patchy distribution through the transverse and descending colon.

At the eight-hour period we noted a slight delay in the terminal ileum with the drug-laden meal but progress through the colonic tract was about the same.

At the end of the twenty-four-hour period the motility with the laxative was much more marked, although the colonic tract, in spite of numerous bowel movements, was not yet completely empty.

At forty-eight hours the colonic tract was completely empty; whereas in the control film there was about 10 per cent retention in the colon.

Résumé: Administration of a single two-dram dose of the fluid extract of cascara produces no alteration in gastric motility. It produces an increased motility through the proximal jejunum. Small intestinal motility is definitely increased during the first three hours while the stomach is emptying, but after gastric evacuation is almost completed the meal moves normally through the small intestines until it reaches the colon. There is slight delay in the terminal ileum. As soon as the laxative meal reaches the colon there is marked rapidity in its passage, so that there is very little retention at the end of twenty-four hours and none at forty-eight hours, while in the control series there is about 10 per cent retention after forty-eight hours.

Discussion: It is interesting to compare this observation with the physiologic action of the drug. As stated above, the alkalinity of the intestinal canal breaks up this drug into those substances to which its laxative action is due. Since the proximal small intestines receive more

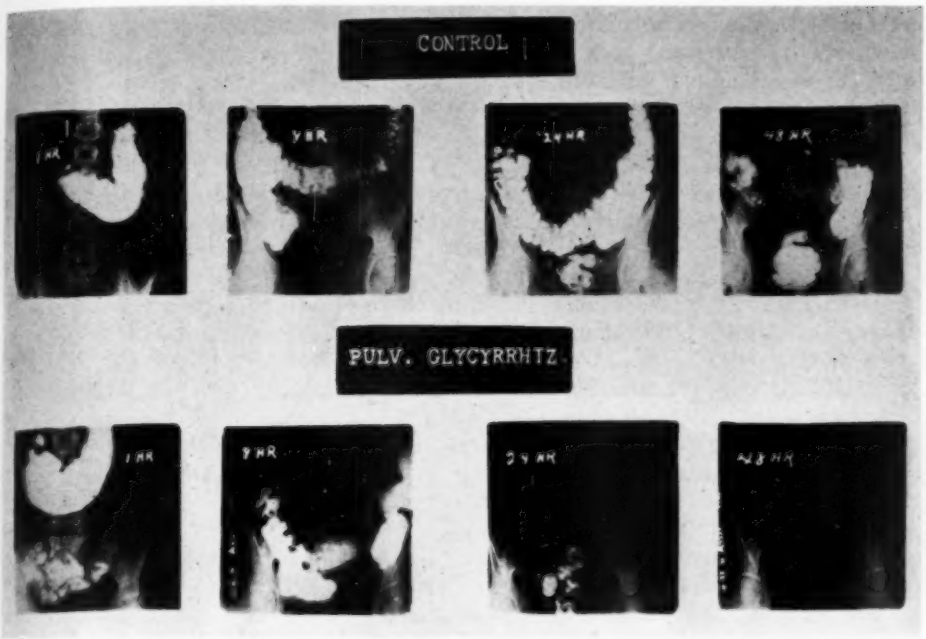

Fig. 2. Effect of Licorice Powder on gastro-intestinal motility.

of the alkaline digestive juices, one would expect a greater action of these substances, which is borne out again by our observations. Our study also bears out the fact that the action of this drug is exerted for the most part in the colonic tract. (Fig. 1.)

LICORICE POWDER

Physiologic Action: Compound licorice powder is similar to cascara in its action but more irritant; it acts chiefly in the large intestine.

Observations: One ounce of licorice powder was administered either immediately before, after, or mixed with six ounces of a water barium mixture in the proportions previously mentioned.

The first films were made ten minutes after ingestion. The amount of gastric retention and degree of gastric motility were the same whether the meal was given with or without the laxative.

At the one-hour period the stomach contained the same amount in both examinations. The laxative-laden opaque meal, however, passed more rapidly through the proximal jejunal coils.

At three hours, in two out of the three cases the amount retained in the stomach was the same as in the control and in one slightly less. The head of the barium column had reached a little further in the ascending colon and there was slightly more in the terminal ileum, indicating slightly increased small intestinal motility.

At four hours the motility through the small intestines and proximal colon was the same, and the head of the barium column had reached the same situation.

At six hours, in both examinations the head of the barium column had reached the cecum, but with the laxative it was slightly further advanced in the ascending colon.

Eight hours after the meal, when most of it had already reached the colonic tract, there was a definite increase in motility with the laxative, so that the head of the barium column was much further advanced.

At twenty-four hours, in two of the three cases there was a very marked in-

crease in colonic motility when the laxative barium mixture was given. In one the motility was about the same, but in this patient there was a general hypomotility at all times.

At forty-eight hours, in two of the three cases there was a very marked increase in motility, with complete emptying in the laxative examinations, whereas there was about 25 per cent retention in the control examination. In the other case, characterized throughout by delayed motility, there was also increased motility but not as marked or as effective as in the first two cases.

Résumé: Licorice powder produces no change in gastric motility as compared with the control. Shortly after its administration, we noted an inability of the proximal jejunal coils to hold the opaque mixture. This passes away by the third hour and after that motility through the small intestine is about the same as in the control. However, when the laxative-laden opaque meal reaches the colon, there is a distinct increase in colonic motility and in forty-eight hours the colon empties much more completely than it does in the control.

Discussion: The study with this drug corroborates the similarity of its action with that of cascara. (Fig. 2.)

MAGNESIUM CITRATE

Physiologic Action: Magnesium citrate is a saline cathartic which is not absorbed—or only slightly absorbed—from the gastrointestinal tract. It is retained in the stomach until it becomes isotonic with the body fluids. It produces considerable transudation in the stomach, increases gastric secretion, inhibits motor function, and delays gastric emptying. In the intestinal tract, this salt, because of its high osmotic pressure, greatly increases the bulk, which acts as a mechanical stimulus, thus accelerating peristalsis and hastening the passage of the contents. The colon antiperistalsis is not inhibited but concentration of the contents does not result, because of the osmotic retention. The fecal matter in the colon is rendered more fluid and this hastens expulsion.

Observations: Six ounces of this laxative were administered immediately after a similar quantity of a barium water mixture. In order to make a reliable comparison the amount of the barium water mixture given in the control study was also increased to twelve ounces instead of eight ounces.

Films were made ten minutes after the ingestion of these meals. With the control meal, gastric emptying began in all three subjects immediately after its ingestion. The meal with the laxative showed delayed motility in all three instances, and in two evacuation had not yet begun at the ten-minute period.

At one hour there was still marked delay in the stomach as compared to the control. Again we noted marked comparative hypermotility through the small intestines, so that the proximal small intestinal coils contained little or none of the opaque meal.

At the three-hour period there was still delayed gastric motility and still increased motility through the proximal small intestinal coils. The opaque meal reached the cecum sooner with the laxative and there was already noted increased motility through the proximal colon.

At four hours there was still some delay in gastric emptying. The passage of the meal through the terminal ileum slowed up to about the normal but colonic hypermotility continued.

At six hours the small intestinal hypermotility originally observed had slowed down so that the amount of retention in the terminal ileum was the same with both meals, but the increased colonic motility with the laxative persisted. The barium column was further advanced in its course through the colon.

At the eight-hour period the terminal ileum showed the same amount of retention, but the colon was still hypermotile as compared to the control.

At twenty-four hours, peculiarly enough, in spite of many bowel movements

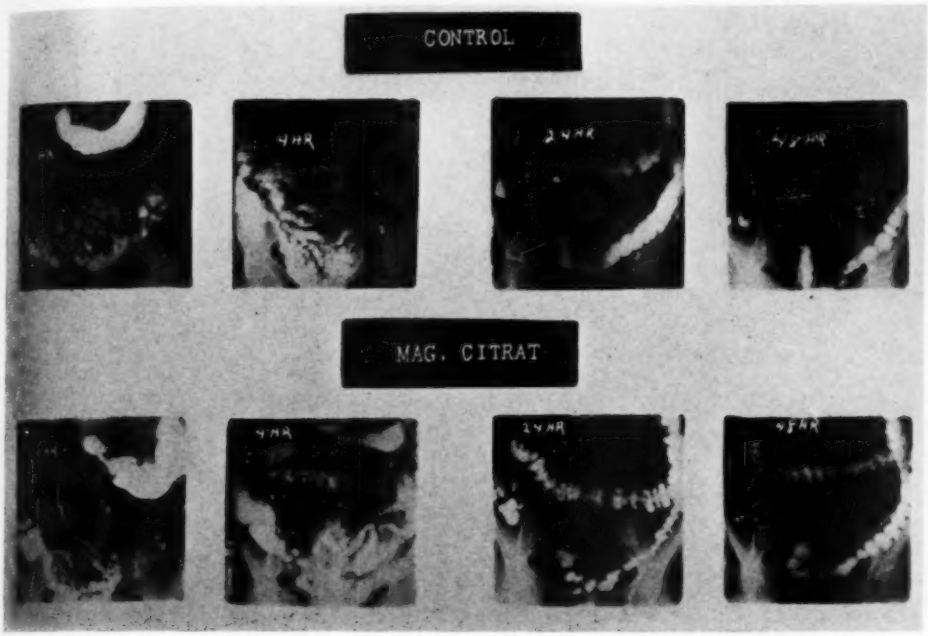

Fig. 3. Effect of Magnesium Citrate on gastro-intestinal motility.

there was, in every instance, just as much retained in the colon after the administration of the laxative as in the control cases.

At forty-eight hours, in spite of the frequent bowel movements and increased motility through the colon, we noted in all three cases just as much retention with the laxative as without, and the amount retained was considerable.

Résumé: Magnesium citrate in all three subjects produced marked delay in gastric emptying. After the meal leaves the stomach it flows rapidly through the proximal jejunum at first. By the four-hour period, although the stomach still shows delayed emptying, the progress through the small intestines is slowed up, and at the six-hour period approximates the control. As soon as the meal reaches the colon there is definite increased motility through the colonic tract so that at all times the head of the barium column is further advanced. In spite of this colonic hypermotility and the increased number of bowel movements, the actual amount of the original meal retained in the colon is the same as the control at the twenty-four- and forty-eight-hour periods. (Fig. 3.)

MAGNESIUM SULPHATE

Physiologic Action: Since magnesium sulphate is also a saline cathartic, its physiologic action is similar to that of magnesium citrate.

Observations: One-half ounce of magnesium sulphate was given immediately before the administration of the opaque meal.

About ten minutes after its ingestion, none of the meal had as yet left the stomach, although in all three control cases an appreciable amount had been evacuated.

One hour later there was marked gastric hypomotility in the cases with the laxative, so that the stomach showed much more retention. The meal laden with the laxative rushed through the proximal jejunal coils so that these were empty in all three cases.

At the three-hour period there was more gastric retention in all laxative cases and in two of the three this was considerable,

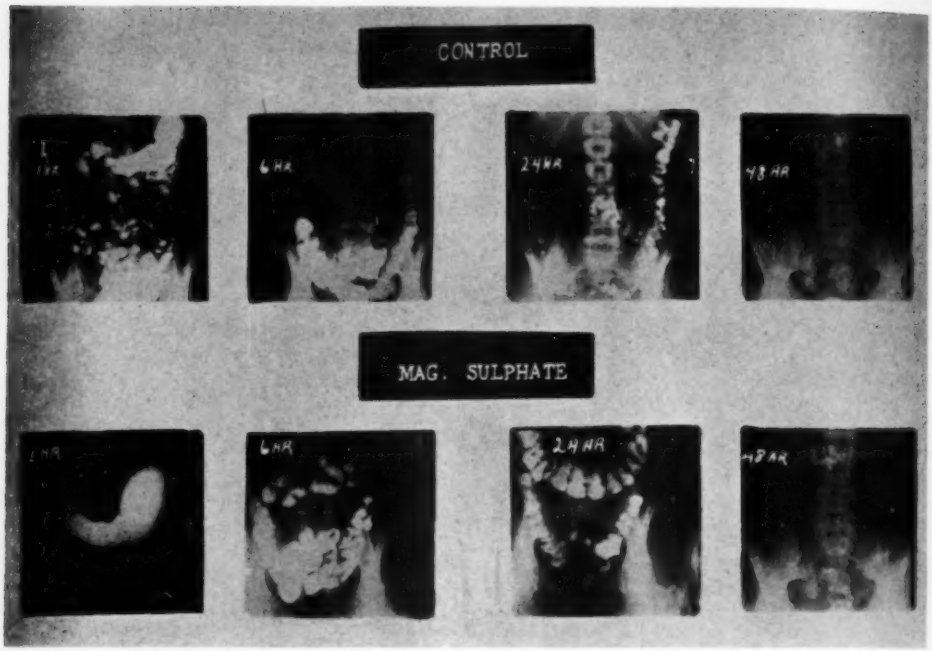

Fig. 4. Effect of Magnesium Sulphate on gastro-intestinal motility.

but the motility through the small intestines was practically the same as for the control series.

At four hours there was definite delay in gastric emptying when this laxative was given. The opaque meal, however, had advanced further in the small intestines and ascending colon than in the control.

At six hours the movement of the laxative-laden meal was delayed through the small intestines and colon, and the meal had advanced much further in the colon without the laxative.

At eight hours, the effect of the laxative was definitely observed. Motility through the colon had increased to such an extent that the barium column had not only overcome the previous hypomotility but actually was further advanced.

At twenty-four hours there was again a delay in the motility of the laxative-laden meal through the colonic tract, so that at this time, in spite of more bowel movements, a larger amount of the meal was retained in the colon than in the control.

At forty-eight hours, in spite of numerous bowel movements, there was still the same amount of meal retained in the colon as without the laxative.

Résumé: With this laxative there is definite delay in gastric emptying. We note again an apparent inability of the jejunum to hold any of the laxative-laden meal for the first hour. Movement of the meal is delayed in the small intestines for eight hours, after which there is an apparent hypermotility through the colon. But at the twenty-four and forty-eight-hour periods the colon contains more of the meal when this laxative is given, in spite of the increased number of bowel movements. This is common to all three cases.

Discussion: As noted above, the physiologic action of magnesium citrate and magnesium sulphate is similar. This is definitely borne out by our observations, and we have corroborated the fact that these drugs delay gastric emptying. We have also observed, as stated above, that these drugs, in spite of producing many

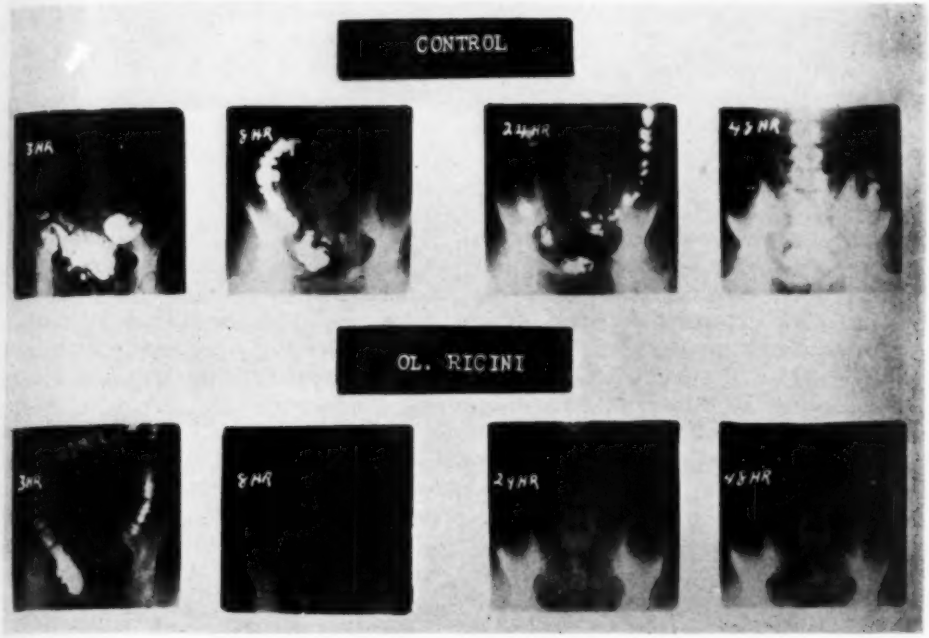

Fig. 5. Effect of Castor Oil on gastro-intestinal motility.

liquid stools, do not empty the colonic contents more quickly, and in some instances not as quickly as when no laxative is given. (Fig. 4.)

CASTOR OIL

Physiologic Action: Castor oil (oleum ricini) slightly delays the passage of food through the stomach, as is the case with all neutral fats. It is saponified in the small intestines to form glycerin and sodium ricinoleate, a soap which stimulates peristalsis. The cathartic effect of castor oil is due mainly to this motor stimulation of the small intestines. The intestinal secretion is not increased, the fluid character of the stools being due to the quick passage of the feces. In the colon the normal antiperistalsis is allayed, so that the feces escape concentration. The propulsive movements of the colon are not much increased, but the passage of the fecal material is hastened by its thinner consistency. The advantages of castor oil are its rapidity of action, thoroughness, comparative freedom from griping, failure to abstract water from the tissues, and its harmlessness if catharsis does not result. It is contra-indicated, however, in pregnancy, for it tends to congest and stimulate the female pelvic organs.

Observations: One ounce of castor oil was administered just before the water barium mixture.

Films were made within ten minutes after its administration. Only a small quantity had left the stomach in both the laxative and control cases.

One hour after the meal two of the three subjects examined had less remaining in the stomach with the laxative, and the other had more. In two of the three laxative cases the proximal jejunal coils were entirely empty in spite of a great deal in the stomach and distal jejunal coils.

At the three-hour period, as compared to the control, the small intestinal coils appeared more segmented. The opaque meal was further advanced along the small intestines, and the head of the barium column was much further advanced in all three

cases, having already reached the sigmoid in each.

At four hours, in one case there was still some gastric residue with the castor oil and again we noted that the meal was further advanced in the colon.

At six hours a good deal of the meal was already evacuated in all three cases examined, with the laxative. Colonic motility was definitely increased, beginning as soon as the meal entered the colon. The amount in the terminal ileum, however, was about the same at both examinations in spite of the fact that the meal moved more quickly through the small intestines with the laxative. This is in all likelihood due to the delayed gastric evacuation.

Eight hours after the ingestion of the meal we noted marked colonic hypermotility. Whereas without the laxative most of the meal was in the proximal half of the colon, with the laxative most of it was in the distal colon and a good deal had already been evacuated.

At twenty-four hours, in two of the three cases the entire colonic tract was empty; in one it contained a small amount. Without the laxative there was about an average amount of retention at this time.

At the forty-eight-hour period, the entire colon was empty with the laxative, whereas without the laxative there was moderate retention in one and a great deal of retention in the others.

Résumé: Castor oil produces definite delay in gastric motility. The meal laden with the laxative passes rapidly through the proximal jejunal coils in the first hour and after that the jejunum holds it fairly well. There is a slight increase in the motility of the laxative meal through the small intestines. When the meal with the laxative reaches the colon, there is very marked hypermotility. The meal passes so rapidly through the colonic tract that in eight hours most of it has reached the sigmoid and rectum and some of it has already been evacuated. Complete emptying of the colonic tract has taken place in twenty-four hours.

Discussion: The results of our study coincide with the physiologic action of castor oil as described above. Briefly, as noted in the discussion of its physiologic action, it causes gastric hypomotility and hypermotility of the small and large intestines. (Fig. 5.)

DISCUSSION

Although the departures from the normal control after the administration of a single dose of a laxative were not markedly striking, yet many interesting observations were recorded. These included not only changes common to all or most of the laxatives, but also certain changes peculiar to each. These latter, with very few exceptions, were constantly observed in all the three cases in which the same laxative was used, so that we may conclude that they were characteristic of the laxative in question.

First, as regards gastric motility, there was no alteration either in increased or decreased motility where a single dose of cascara and licorice powder was given. Castor oil and both magnesium salts—the citrate and the sulphate—produced delay in gastric motility.

In all cases, with all the five laxatives, the proximal jejunum was apparently so irritated when the laxative-laden meal reached it that for the first one to three hours it did not retain enough of the meal for good visualization. After that time its irritability was apparently diminished and its motility approached the normal. In the patients who were given magnesium sulphate there was definite delay in the passage of the meal through the small intestines, in the other four small intestinal motility was slightly increased.

When the meal reached the colonic tract, there was hypermotility in all cases but the end phenomenon differed considerably with different laxatives, although all the patients had a definite diarrhea, with numerous bowel movements.

After the administration of cascara the colonic tract was almost empty at twenty-four hours, completely so at forty-eight

hours, but the normal patients had only 20 per cent retention in forty-eight hours.

With licorice powder and castor oil there was much more complete evacuation of the colon and much less retention at the end of both the twenty-four- and forty-eight-hour periods, particularly so with castor oil.

With the two magnesium salts, although bowel movements were numerous, the amount of actual retention at the end of forty-eight hours was the same as without the laxative when magnesium citrate was given and more than with the laxative when magnesium sulphate was given.

CONCLUSIONS

1. A study of gastro-intestinal motility following the administration of a single dose of commonly used laxatives was made.

2. The laxatives studied were cascara, licorice powder, magnesium citrate, magnesium sulphate, and castor oil.

3. Three normal individuals were studied for each laxative; a total of fifteen cases.

4. A control study of each individual was made about a week or ten days preceding the study with a laxative.

5. Films were made immediately, and at one hour, three hours, four hours, six hours, eight hours, twenty-four hours, and forty-eight hours after the meal.

6. Fluid extract cascara and compound licorice powder produced no alteration in gastric evacuating time as compared to the control. The magnesium salts—both citrate and sulphate—and castor oil produced delayed gastric motility.

7. All laxatives produced an initial irritability of the proximal jejunum lasting one to three hours.

8. With magnesium sulphate there was definite delay in the passage of the meal through the small intestines. The other laxatives showed moderately increased small intestinal motility.

9. Fluid extract cascara showed a slightly increased emptying of the colon.

Compound licorice powder and castor oil, of all five laxatives used, produced the most satisfactory and complete emptying of the colon.

The two magnesium salts showed more retention at forty-eight hours than the control, in spite of numerous bowel movements.

10. From the above study, one would conclude that castor oil and compound licorice powder are the best laxatives for colonic cleansing in preparation for x-ray examinations.

We are indebted to the fifteen normal persons who kindly volunteered for this study, to Miss Betty Amey and Miss Hazel Aull for the technical work involved, and to Mr. Morris Skarupsky for the illustrations.

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BIBLIOGRAPHY

1. BASTEDO, W. A.: Materia Medica, Pharmacology, Therapeutics, and Prescription Writing. Philadelphia, W. B. Saunders Co., 4th Ed., 1937.
2. MAGNUS, R.: Arch. f. d. ges. Physiol. **123:** 99–112, 1908.
3. MAGNUS, R.: Therap. Monatsh. **123:** 654–658, December 1909.
4. OTT, I., AND SCOTT, J. C.: Action of Phenolphthalein, Cascara Sagrada, and Ergot on Intestinal Movements. Med. Bull. **30:** 90–92, 1908.
5. SOLLMANN, T.: A Manual of Pharmacology. Philadelphia, W. B. Saunders Co., 4th Ed., 1932.
6. SOLLMAN, T., AND RADEMAEKERS, A.: Investigations on Saline Cathartics. Arch. internat. pharm. dyn., Paris **31:** 39, 1925–26.
7. WRIGHT, H. N., AND MONTAG, M.: A Text Book of Materia Medica, Pharmacology and Therapeutics. Philadelphia, W. B. Saunders Co., 1939.

Roentgen Diagnosis of Spontaneous Internal Biliary Fistulae, Especially Those Involving the Common Duct[1]

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SPONTANEOUS internal biliary fistulae are not common. In a series of 10,866 autopsies reported by Roth, Schroeder, and Schloth (33) only 43 cases were found. These fistulae may occur between the gallbladder or common duct and any of the adjacent portions of the gastrointestinal tract, stomach, duodenum, or colon. Fistulae between the gallbladder and duodenum are the most common; those between the gallbladder and colon are next in frequency; those between the gallbladder and stomach and those involving the common duct are rarer. In a series of 200 cases of internal biliary fistulae reported by Naunyn (27), 93 were cholecystoduodenal; 49 cholecystocolic; 8 cholecystogastric; and 15 choledochoduodenal.

Fig. 1. Plain film of abdomen of female aged 58 who had symptoms of acute intestinal obstruction. Several dilated loops of jejunum are visible, terminating in a faint annular shadow, 2 cm. in diameter, on the left of the third lumbar vertebra (an impacted gallstone). A sister gallstone can be faintly discerned in the gallbladder region. These findings are indicative of spontaneous internal biliary fistula.

The roentgen diagnosis of spontaneous internal biliary fistula has been made in many instances. The first case so diagnosed was reported by Hunt and Herbst (18) in 1915, and was shortly followed by a case described by Carman and Miller (9). Prior to 1930 only a few examples were recorded, but since that time reports have been increasingly numerous. In a series of fistulae reported by Judd and Burden (20) in 1925, only one out of 153 had been demonstrated by x-ray examination. Having been fortunate enough to recognize several cases *in vivo*, we were attracted to the problem of differentiating the exact anatomical type of fistula present, with special attention to the correct diagnosis of chole*docho*-enteric fistulae.

Of 10 cases of spontaneous internal biliary fistula found in the records of the San Francisco Hospital from 1931 to 1940, 7 were examined roentgenologically, and 5 of these were correctly diagnosed at the first visit to the department. Two of these fistulae were found to be of the choledochoduodenal type. The details of these cases are summarized in Table I.

In 1934 Sickels and Hudson (34) reported the correct roentgen diagnosis of a spontaneous internal biliary fistula and reviewed the literature on 29 other cases which had been so diagnosed. A recent review reveals that 55 additional cases of spontaneous internal biliary fistula have been so diagnosed, which, with the 5 roentgenologically diagnosed cases reported here, make a total of 90 cases which have been disclosed by x-ray examination. Table II classifies these cases according to the type of fistula found, and its cause or apparent cause. From this table it is seen

[1] From the Department of Medicine (Radiology), Stanford University Medical School, and the Department of Public Health, San Francisco Hospital (J. C. Geiger, M.D., Director). Accepted for publication in July 1941.

TABLE I: CASES OF SPONTANEOUS INTERNAL BILIARY FISTULA SEEN AT THE SAN FRANCISCO HOSPITAL 1931–1940

Case	Age	Sex	Diagnosis	Etiology	Verification	X-ray Diagnosis
1	45	M	Choledochoduodenal fistula	Perforation of ulcer into common duct	X-ray	Choledochoduodenal fistula
2	34	M	Choledochoduodenal fistula	Perforation of ulcer into common duct	X-ray and surgery	Cholecystoduodenal fistula, spontaneous. Duodenal ulcer
3	75	F	Cholecystoduodenal fistula	Carcinoma of the pancreas	Surgery and x-ray	Cholecystoduodenal fistula. Carcinoma at head of pancreas
4	59	F	Cholecystoduodenocolic fistula	Carcinoma of the gallbladder	Surgery, x-ray, and biopsy	Enterocolic fistula. (The gallbladder and ducts were not visible)*
5	73	M	Cholecystoduodenal fistula	Large stone ulcerated through the gallbladder into duodenum	Autopsy	Duodenal ulcer and duodenal diverticulum (latter in second portion)†
6	71	F	Cholecystoduodenal fistula	Carcinoma of the pancreas	Clinical and x-ray (no autopsy)	Cholecystoduodenal fistula
7	85	M	Cholecystoduodenal fistula	Not known	X-ray	Cholecystoduodenal fistula
8	60	F	Cholecystoduodenal fistula	Carcinoma of the gallbladder	Autopsy	Not examined
9	36	F	Cholecystoduodenal abdominal fistula	Right upper abdominal abscess following appendectomy	Surgery	Not examined
10	69	F	Cholecystogastric fistula	Empyema of the gallbladder	Surgery	Not examined

* This patient was examined first by opaque enema and then by routine gastro-intestinal study. At no time during the examination did the gallbladder or any of the ducts contain air or barium. The proximal end of the transverse colon communicated with the second portion of the duodenum (and, at operation, was seen to connect with the gallbladder also, due to carcinoma of that viscus, with extension to both duodenum and colon).

† This patient was examined by routine gastro-intestinal study. The pyloric end of the stomach and the first portion of the duodenum were grossly irregular in outline, the deformity being quite bizarre. The resident who examined the patient diagnosed juxtapyloric ulcer and duodenal diverticulum. Upon restudying the films some weeks later it was seen that part of the "duodenal" irregularity was actually due to a barium-filled gallbladder and cystic duct, overlapping the shadow of the barium-filled duodenum. The correct x-ray diagnosis was then made. At autopsy, the patient had all three lesions, namely duodenal ulcer, duodenal diverticulum, and cholecystoduodenal fistula secondary to gallstone ulceration! He died from peritonitis resulting from a low *ileal* perforation of a gallstone which had successfully negotiated the intestinal tract down to that point.

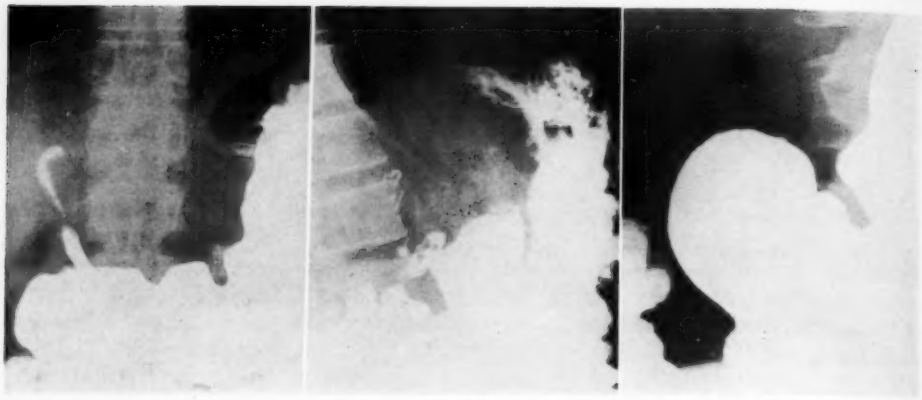
that while chole*cysto*duodenal fistula is the most usual type, chole*docho*duodenal fistula is of relatively more frequent occurrence than is indicated by pathological and surgical reports.

ETIOLOGY

The most common cause of these fistulae is calculous perforation. This holds true particularly for the cholecystoduodenal fistulae. Perforating peptic ulcers are also a frequent cause. A few cases are due to carcinoma, either of the gallbladder or stomach, and still fewer to infection, such as acute cholecystitis or empyema of the gallbladder. In Judd and Burden's report of 153 cases the presence of gallbladder calculi as the causative factor was observed in all but 23 cases. In the entire series which we reviewed it was found that perforating peptic ulcer was the etiological factor in 26 cases or approximately 33 per cent. This is by far the most common cause of the chole*docho*duodenal fistula.

DIAGNOSIS

The roentgen diagnosis of spontaneous internal biliary fistula depends upon the detection of the outline of the gallbladder or parts of the biliary tree, either by air, gas, or some opaque medium such as barium sulphate. In a few cases the condition has been inferred from the presence of opaque biliary calculi in the small or large bowel (Fig. 1); one of us has seen



A B C

Fig. 2. Case I: Male, aged 45, without symptoms referable to the stomach or biliary tract. Six weeks previously this patient entered the hospital with a perforated juxtapyloric ulcer, which was closed surgically. These films were made as part of a routine postoperative check-up. Figure A shows the stomach distended with barium sulphate suspension, some barium in the common and hepatic ducts, and some air or gas in the gallbladder. Figure B is an oblique projection, showing deformity of the bulb, probably partly due to the old ulcer and partly to postoperative changes; a few small hepatic ducts are visible overlying the margin of the twelfth thoracic vertebral body. Figure C is a spot film made in the erect position, revealing some bile or other fluid, plus gas or air, in the gallbladder. Spontaneous internal biliary fistula, probably choledocho-duodenal. This gallbladder had been examined at operation and was found to be normal; the communication apparently connected the common duct with the duodenum.

three cases of small bowel obstruction due to biliary calculus, in which the presence of air or gas in the biliary tree was noted some days after the stone had passed or been removed.[2] Nine cases in the entire series under review were reported to have been diagnosed by air in the biliary ducts alone. The presence of some opaque contrast medium or air in the hepatic ducts or gallbladder is said to result occasionally from reflux up through the ampulla of Vater; we have never seen this ourselves, and in the illustrations accompanying the reported cases usually only the lower portion of the common duct is seen. We have, however, seen two cases of gas filled gallbladder due to acute emphysematous cholecystitis (reported elsewhere by one of our colleagues, Dr. E. Fong). In the true fistulae some of the intrahepatic biliary tree is usually seen; in the "reflux" cases this is rarely or never so, only the distal portion of the common duct or the ampulla itself being filled.

The diagnosis of the exact anatomical type of fistula is often difficult, but is somewhat aided by the associated findings. If a gallstone can be detected or there is a reliable history of its presence, a spontaneous internal biliary fistula is apt to be cholecystoduodenal. If no stone is present and there is definite evidence or re-

[2] To be reported in a separate publication.

TABLE II: CLASSIFICATION OF REPORTED CASES OF SPONTANEOUS INTERNAL BILIARY FISTULA DIAGNOSED BY X-RAY EXAMINATION

(Including the five cases reported in this paper)

Type of Fistula	Apparent Cause					
	Cholelithiasis	Peptic Ulcer	Carcinoma	Infection	Cause Not Given	Total
1. Cholecystogastric	2				1	3
2. Cholecystoduodenal	25	6	5	4	6	46
3. Cholecystocolic	6				4	10
4. Cholecystoduodenocolic	1					1
5. Choledochogastric		1				1
6. Choledochoduodenal	3	19		1	1	24
7. Choledochocolic	1					1
8. Indeterminate			1		3	4
TOTAL	38	26	6	5	15	90

liable prior diagnosis of duodenal ulcer, the fistula is likely to be choledochoduodenal. In the entire series under review, there were 24 cases of choledochoduodenal fistulae and 19 of these were due to perforating ulcer.

CASE REPORTS

In our series from the San Francisco Hospital two cases were diagnosed as choledochoduodenal fistulae.

CASE I: A 45-year-old male entered the San Francisco Hospital on Sept. 28, 1940, complaining of sudden severe epigastric pain of three hours' duration. The abdomen was rigid and there was tympany over the liver. The history was suggestive of peptic ulcer for eight years. X-ray examination showed a large amount of free air under the diaphragm. Operation revealed a large pyloric ulcer with a perforation 2 mm. in diameter; this was closed. The gallbladder appeared to be normal. Recovery was uneventful.

The patient returned on Nov. 15, 1940, a month and a half following operation, free of gastro-intestinal symptoms. Routine postoperative check-up gastro-intestinal examination (Fig. 2) disclosed an irregular duodenal bulb with a small niche, demonstrable only by compression. Fluoroscopically, barium was seen to pass from the duodenal bulb into the common duct, and thence into the hepatic ducts. In the films, the gallbladder was seen to contain some air and fluid, and there was also some air in the hepatic ducts. The 6-hour and 24-hour films showed a small amount of air and barium in the biliary ducts. The diagnosis was choledochoduodenal fistula, probably the result of perforation of duodenal ulcer into the common duct.

CASE II: A 34-year-old white male laborer entered the San Francisco Hospital on April 1, 1940, complaining of a gnawing epigastric pain which was relieved by food and medication. A roentgen diagnosis of penetrating duodenal ulcer had been made in 1934. There had been frequent recurrences of symptoms in the interval, associated with tarry stools. Three weeks prior to entry the pain had become very severe, stabbing and sharp, confined mainly to the epigastrium, and referred to the back. Gastro-intestinal examination on April 23 (Fig. 3) showed the duodenal bulb to be small and deformed. The biliary tract, including the hepatic and cystic ducts and gallbladder, filled immediately after the barium entered the duodenum. The diagnosis was cholecystoduodenal fistula, probably the result of perforation of duodenal ulcer into the gallbladder. (On review we believe we should have diagnosed this case as probable chole*dochho*duodenal fistula.)

The patient was operated upon on May 4, 1940, and a gastric resection was done. In the first portion of the duodenum an area of induration was found surrounding a duodenal ulcer; the latter was adherent to the pancreas in the region of the common duct. The gallbladder appeared normal. No attempt was made to disturb the duodenobiliary fistula. The postoperative diagnosis was duodenal ulcer, probably perforating into the common duct.

Fig. 3. Case II: Male, aged 34, complaining of intermittent epigastric pain, relieved by food. Roentgen examination disclosed a small, deformed duodenal bulb, with an ulcer niche; at fluoroscopic examination the common and hepatic ducts filled promptly, and then the gallbladder. Diagnosis: Spontaneous internal biliary fistula, probably choledochoduodenal. This patient was operated upon eleven days later, a gastric resection being performed. In the first portion of the duodenum a duodenal ulcer, adherent to the pancreas in the region of the common duct, was found. The gallbladder appeared normal. No attempt was made to disturb the fistula. Recovery was uneventful.

Although in neither of these cases could a definite fistulous tract be demonstrated at operation, the visibility of a normal gallbladder in the presence of the existing x-ray findings is strongly presumptive evidence of chole*dochho*duodenal fistula.

SUMMARY

Ten cases of spontaneous biliary fistula were seen at the San Francisco Hospital during the nine-year period from 1931 to 1940. Seven of these were examined radiologically. In five, the correct diagnosis was made, in one it was overlooked

(but should have been made), and in one the fistula was not patent at the time of examination and, therefore, could not have been detected.

An attempt was made to differentiate chole*docho*-enteric fistula from chole*cysto*-enteric fistula. Two cases of choledocho-enteric fistula were encountered and in one the correct diagnosis was made by x-ray examination. Inasmuch as choledocho-enteric fistulae are usually due to peptic ulcer, while cholecysto-enteric fistulae are usually attributable to calculous perforation, we believe that the differential diagnosis has a practical value. The prognosis in fistulae secondary to gallstone ulceration is potentially poor, since stones in such cases may obstruct and even ulcerate through the intestinal tract lower down (especially in the terminal ileum). On the other hand, fistulae secondary to peptic ulcer, such as most choledochoduodenal fistulae, tend to have a relatively good prognosis, at least as far as remote complications are concerned. Either type may heal spontaneously.

Spontaneous internal biliary fistula is probably much more common than would be suspected from the number of cases reported and deserves bearing in mind by radiologists pursuing gastro-intestinal diagnosis.

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San Francisco, Calif.

BIBLIOGRAPHY

1. ALTMAN, W. S., AND FIELD, E. A.: Spontaneous Internal Biliary Fistula, Report of Two Cases. New England J. Med. **216:** 199–202, February 1937.

2. BELTRAMETTI, L.: Cholecystoduodenal Fistula: Clinical and Roentgenologic Study. Arch. ital. d. mal. d. app. diger. **4:** 171–182, June 1935.

3. BENGOLEA, A. J., AND VELASCO SUÁREZ, G.: Cholecystoduodenal Fistula due to Biliary Lithiasis. Arch. argent. de enferm. d. ap. digest. y de la nutrición **9:** 123–136, December 1933.

4. BIGNAMI, G., AND AGATI, D.: Choledochoduodenal Fistula, Roentgen Study. Ann. di radiol. e fis. med. **8:** 524–558, October 1934.

5. BLEFARI-MELAZZI, T.: Radiologic Observation of Communication between Gallbladder, Duodenum, and Colon. Radiol. med. **21:** 1136–1146, October 1934.

6. BORMAN, C. N., AND RIGLER, L. G.: Spontaneous Internal Biliary Fistula and Gallstone Obstruction. Surgery **1:** 349–378, March 1937.

7. BUTUREANU, W., BARTH, C., AND GATOSCHI, G.: Duodenal Ulcer Perforating into Extrahepatic Bile Ducts. Choledochoduodenal Fistula. Presse méd. **44:** 2109–2110, Dec. 26, 1936.

8. CANDEL, S., AND WOLFSON, W. L.: Air in the Bile Passages: Review and Report of Case. J. A. M. A. **105:** 188–190, July 20, 1935.

9. CARMAN, R. D., AND MILLER, A.: Roentgen Diagnosis of Diseases of the Alimentary Canal. Philadelphia, W. B. Saunders Co., 1917.

10. CAPUA, A.: Roentgen and Surgical Study of Case of Choledochoduodenal Fistula. Arch. ital. d. mal. d. app. diger. **2:** 85–94, May 1933.

11. CASTILLO, P. A.: Cholecystoduodenal Fistula. Arch. de med. int. **2:** 161–227, 1936.

12. CRISTOFANETTI, P.: Spontaneous Injection of Opaque Liquid into the Biliary Tract during Roentgen Study of Digestive Tract Due to Fistula. Quaderni radiol. **3:** 268–277, 1938.

13. DANZER, J. T.: Preoperative Diagnosis of Cholecystocolonic Fistula. Radiology **28:** 88–89, January 1937.

14. DASSEN, R.: Cholecystogastric Fistula. Semana méd. **1:** 628–630, March 1, 1934.

15. DU MESNIL DE ROCHEMONT, R.: Roentgen Demonstration of Fistulas between Bile Passages and Digestive Canal. Röntgenpraxis **11:** 156–165, March 1939.

16. WYBERT, A., AND GARRÈ, E. S.: Case of Biliary Ileus. Arch. argent. de enferm. d. ap. digest. y de la nutrición **11:** 316–323, February-March 1936.

17. GIACOBINI, A.: Duodenocholedochal Fistula: Roentgen Study. Riv. osp. **27:** 603–624, November 1937.

18. HUNT AND HERBST: Quoted by Borman and Rigler.

19. IMPALLOMENI, R.: Cholecystoduodenal Fistula, with Roentgen Study of Case. Radiol. med. **24:** 958–970, November 1937.

20. JUDD, E. S., AND BURDEN, V. G.: Internal Biliary Fistula. Ann. Surg. **81:** 305–312, January 1925.

21. KÖBERLE, F.: Internal Fistula Developing on Base of Ulcer. Arch. f. klin. Chir. **192:** 572–580, 1938.

22. KUGELMEIER, L. M.: Spontaneous Internal Fistulas. Röntgenpraxis **10:** 729–739, November 1938.

23. LENK, R.: Air-filled Gallbladder and Bile Ducts in Fistula of Gallbladder. Röntgenpraxis **9:** 830–831, 1937.

24. MALLET-GUY, P., AND MAILLET: Roentgen Diagnosis and Treatment of Cholecystoduodenal Fistula. Lyon chir. **36:** 602–606, 1940.

25. MEESE, J.: Post-operative Choledochoduodenal Fistula. Röntgenpraxis **7:** 690–692, October 1935.

26. MEDELMAN, J. P.: Cholecystocolic Fistula: Case Report. Am. J. Roentgenol. **36:** 52–54, July 1936.

27. NAUNYN: Quoted by Judd and Burden.

28. ORTMAYER, M., STETLER, P. M., AND GIRYOTAS, E.: Visualization of Spontaneous Internal Fistula of Biliary Tract by Roentgen Rays. J. A. M. A. **114:** 1055–1058, March 23, 1940.

29. PAUL, L. W.: Cholecysto-duodenal Fistula with Gallstone Obstruction of Small Intestine: Report of Two Cases. Radiology **23:** 363–365, September 1934.

30. PODLASKY, H. B.: Biliary Colic Fistula. Radiology **24:** 345–349, March 1935.

31. POHLANDT, K.: Cholecystogastric Fistula from Gallbladder Calculus. Beitr. z. klin. Chir. **159:** 138–147, 1934.

32. POWERS, R. A.: Air in the Hepatic Ducts. Radiology **27:** 474–478, October 1936.

33. ROTH, SCHROEDER, AND SCHLOTH: Quoted by Judd and Burden.

34. SICKELS, T. N., AND HUDSON, C. L.: Demonstration of a Spontaneous Internal Biliary Fistula by Roentgen Examination: Report of Case. Am. J. Roentgenol. **31:** 31–36, January 1934.

35. STARTZ, I. S.: Cholecystic-colonic Fistula, Report of Case. Am. J. Roentgenol. **36:** 518–520, October 1936.

36. STEVENSON, C. A., AND SHERWOOD, M. W.: Roentgen Diagnosis of Cholecystocolic Fistula. Radiology **35:** 616–621, November 1940.

37. STEUR, K.: Cholecystoduodenal Fistula with Duodenal Diverticulum. Röntgenpraxis **8:** 818–819, December 1936.

38. VELASCO SUAREZ, C., AND BAZTERRICA, E.: Bouveret's Syndrome. Arch. argent. de enferm. d. ap. digest. y de la nutrición **13:** 55–62, October-November, 1937.

39. VORHAUS, M. G., AND ROGERS, A. E. T.: Cholecystocolic Fistula with X-Ray Demonstration. Am. J. Digest. Dis., & Nutrition **1:** 133–134, April 1934.

40. ZAVALETA, D. E., MALENCHENI, M., AND CURUTCHET, J. L.: Duodenal Ulcer Perforated into Choledochus; Formation of Choledochoduodenal Fistula. Semana méd. **1:** 304–313, Feb. 9, 1939.

Calcification and Ossification of Vertebral Ligaments (Spondylitis Ossificans Ligamentosa): Roentgen Study of Pathogenesis and Clinical Significance[1]

ALBERT OPPENHEIMER, M.D.

CALCIFICATION and ossification of the vertebral ligaments are common phenomena, between which a clear distinction is not usually made. Their pathogenesis is disputable. Léri observed that the ligaments may calcify or ossify when they sustain increased tension, when they are torn, or when they are involved in lesions of vertebral bone or joints (9). He inferred that calcification and ossification of the ligaments are modes of healing which help to consolidate a weakened vertebral column, whereby he implied that they are consecutive to other vertebral lesions. Simmonds believed that calcification and ossification may also occur independently, as a primary "syndesmosis" (18). This view reappears in Knaggs' classification as *spondylitis ossificans ligamentosa* (8). Schmorl stated that increased tension upon certain fibers of the longitudinal ligaments induces the formation of osteophytes at the vertebral edges (17). Supporting this theory, Beadle assumed that vertebral osteophytes—one of the most common lesions of the spine—are, in reality, ossified fibers of the anterior longitudinal ligament (3). This would confirm Léri's view that vertebral ligaments may ossify when they are strained, although his results seem to have been unknown to Schmorl and Beadle. Calcification and ossification of undetermined origin in the posterior longitudinal (12, 14, 17), interspinal (17), and yellow ligaments (ligamenta flava) (2, 5, 9, 11, 12) have also been recorded.

Clinically, it is held that in a region with calcified or ossified ligaments vertebral mobility is diminished or absent. Thus ossification of the longitudinal ligaments is believed to cause the vertebral rigidity which is typical of rhizomelic spondylosis (Strümpell-Marie disease of the American, or Bechterew disease[2] of the German, nomenclature). But Fraenkel showed as early as 1903 that this syndrome is produced by, or associated with, an ankylosing inflammation of the apophyseal joints, *spondylarthritis ankylopoietica*, which is not necessarily accompanied by ossification of ligaments (7). Thickening and calcification of lumbosacral ligamenta flava were held responsible by Léri (9) for certain forms of enuresis, and by Brown (5) and Naffziger, Inman, and Saunders (11) for pain low in the back; but both Léri himself (9) and Bakke (1) reported that this lesion may also occur in the absence of any clinical manifestations.

These differences of opinion seem to arise from two main sources. First, no control series has as yet been published to substantiate the various theories. Second, most views are based upon postmortem findings. There would seem, however, to be few hypotheses that could not be supported by an analysis of vertebral specimens, since the reactions which occur in the vertebrae in the course of a chronic lesion are uncharacteristic, variable, and in most cases overlapping. It is necessary to watch the development of the lesions during life in order to acquire information as to their nature and pathogenesis.

This attempt has been made in the study here recorded. The report is concerned chiefly with three questions: 1. In which

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[2] von Bechterew's reports are so ambiguous that "Bechterew disease" has come to imply in English (8) and French (9) a certain type of senile kyphosis (*spondylitis muscularis* and *kyphose hérédo-traumatique*), but in German (17) ankylopoietic spondylarthritis, synonymous with rhizomelic spondylosis and with Strümpell-Marie disease. This difference is not always appreciated (3). von Bechterew's findings could not be confirmed (19). Defining neither a clinical nor an anatomic entity, the confusing term had better not be used any longer.

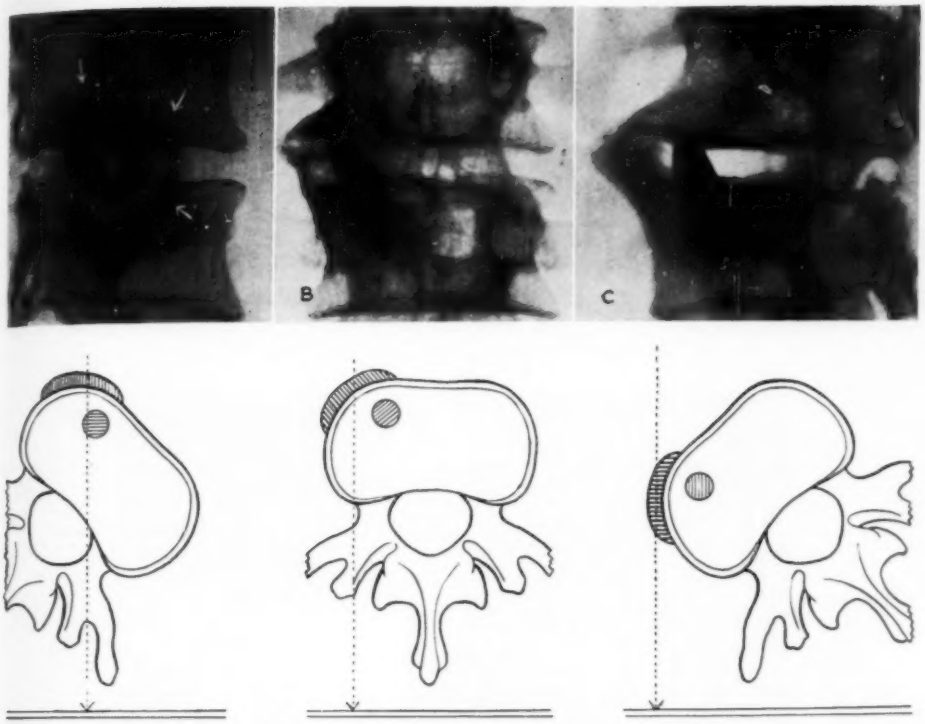

Fig. 1. A bullet lodged in the 3rd lumbar vertebral body, reaching through the superjacent disc to the lower surface of the 2nd lumbar vertebra. Longitudinal ligament calcified or ossified on the side which is close to the bullet; no calcification or ossification on the other side. Roentgenograms taken in the positions indicated by the corresponding diagrams. The calcified or ossified area is conspicuous in the tangential projection (C), but only faintly visible when crossed perpendicularly by the central ray (white arrows in A).

conditions do the vertebral ligaments calcify or ossify? 2. How are calcification and ossification of vertebral ligaments related to lesions of the vertebral bodies, intervertebral discs, and apophyseal joints? 3. Do calcification and ossification of vertebral ligaments produce stiffness of the back, pain, and radicular symptoms?

METHOD

Two hundred and eighty-two persons between the ages of fourteen and eighty-four years with definite calcification or ossification of vertebral ligaments were examined clinically and roentgenologically, many of them several times at variable intervals. Vertebral mobility was tested in every case and recorded on photographs in 42 and on roentgenograms in 21 persons.

Since calcified ligaments are best seen (Fig. 1) when projected tangentially (5), lateral views were made for demonstrating the anterior and posterior longitudinal ligaments, and oblique views to show the ligamenta flava and the lateral fibers of the longitudinal ligaments

Calcification cannot usually be distinguished from ossification on the roentgenogram. Slight or small calcified or ossified areas are not always opaque enough to become visible through the intervening tissues, especially when these are dense. Hence only definite calcifications or ossifications, but no borderline cases, have been considered here.

RELATION TO LESIONS OF VERTEBRAL BODIES

The longitudinal ligaments are often found to be calcified or ossified in the presence of vertebral infections, *e.g.*, at the

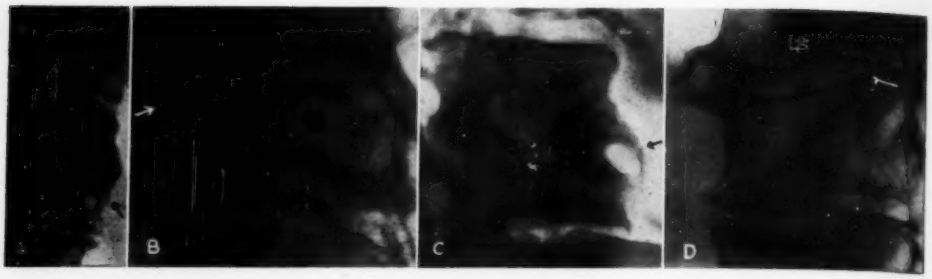

Fig. 2. The ligaments may ossify or calcify in the presence of many different lesions of the vertebral bodies, *e.g.*, in the presence of subluxation (A), metastases of malignant thymoma (B), tuberculosis (C), or chronic staphylococcic osteitis (D).

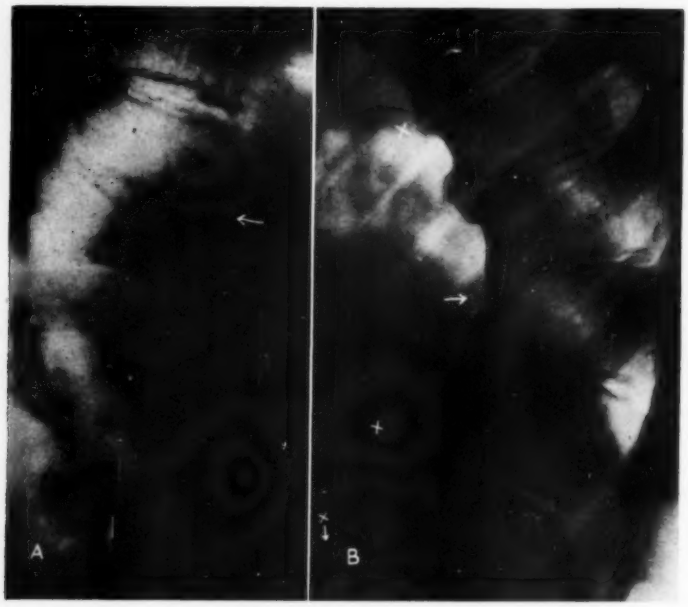

Fig. 3. The ligaments may calcify or ossify at the vertex of a kyphotic concavity. A. Senile kyphosis with osteoporosis and partial collapse of vertebral bodies, and with biconcave "fish" vertebrae due to expansion of the normal discs. B. Juvenile kyphosis or Scheuermann disease with erosion and partial detachment of the annular epiphyses (x). Note that in both cases the calcification or ossification of the longitudinal ligament is confined to the areas of greatest concavity (see text).

level of vertebrae involved by tuberculous, typhoid, or chronic staphylococcic osteitis (Fig. 2), and in the presence of syphilis and Malta fever. Calcification or ossification may also develop after fractures, dislocations (Fig. 2), or other traumatic injuries of the vertebral bodies (Fig. 1). Less commonly, the ligaments calcify or ossify around vertebrae which are invaded by tumor metastases (Fig. 2). The extensive calcification or ossification which may be present in cases of juvenile or senile kyphosis is usually most pronounced at the vertex of the concavity (Fig. 3), that is, at the dorsolumbar junction or in the lower thoracic region; it always begins at, and usually remains confined to, this site, and it may be followed by bony union between

the ventral parts of the vertebral bodies (8, 9, 17).

In all these morbid conditions it usually takes from three months to several years for the calcification or ossification to form. Following fractures, calcification or ossification may become definite as early as six weeks after the injury; in the presence of a chronic infection, such as tuberculosis, several years usually elapse before calcification or ossification develops. This difference is obviously due to the fact that the morbid reaction induced by a traumatic injury does not last as long as a reaction caused by chronic or recurrent infection, and it suggests that calcification or ossification of ligaments takes place at the healing stage of a vertebral lesion.

The observations show that calcification or ossification of ligaments may occur in the course of many different lesions of the vertebral body, irrespective of their etiology.

RELATION TO LESIONS OF INTERVERTEBRAL DISCS

It has been known for a long time (15, 20) that osteophytes may develop at the edges of the vertebral bodies at the level of flattened intervertebral discs. The fact that the osteophytes extend along the longitudinal ligament, as noted by Beneke (4), was ascribed by Schmorl (17) to straining of the fibers which connect the vertebral edge with the disc and ligament. Beadle stated that this strain is the result of an increased mobility of the vertebrae at the level of thinned discs (3). This view is now generally accepted (16). Since osteophytes may be absent at the level of flattened discs, and present at the level of normal discs, Schmorl assumed that thinning of the disc is only a factor predisposing to, but not always leading to, straining of ligaments, wherefore osteophytes need not form in every case. The presence of osteophytes at vertebrae with normal discs was not taken into account by Beadle. Schmorl and Junghanns assert that osteophytes induced by disc thinning arise at the insertion of the longitudinal ligament, whereas osteophytes of different origin form at the very edge of the vertebra. But according to the writer's observations, osteophytes at the level of undoubtedly normal discs may arise at the insertion of the ligament (Fig. 4), and osteophytes at the level of flattened discs may form at the vertebral edge itself (Fig. 4).

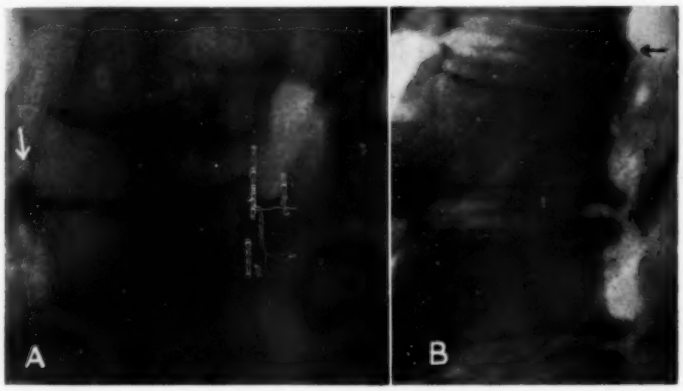

Fig. 4. The localization and shape of osteophytes are independent of the condition of the discs (see text). Thorn-shaped ossification arising at the insertion of the anterior longitudinal ligament in the presence of a normal disc (A), and osteophytes arising at the very edge of the vertebral bodies at the level of flattened discs (B).

It is possible that in the cadaver the vertebrae adjacent to a thinned disc may be more movable than normal, as reported

Fig. 5. Osteophytes develop, and ligaments calcify or ossify, on the side on which the tension of ligaments is diminished (see text). Note the presence of osteophytes and condensation on the concave side and their absence on the convex side. A case of unilateral thinning of intervertebral discs with consecutive scoliosis.

by Beadle. During life, however, these vertebrae are usually less movable than those with normal discs, as revealed by roentgenographic records (12). Since superincumbent parts press the vertebrae together when the intervening disc is thinned, the articular and spinous processes, which normally set a limit to flexion, extension, and rotation, are so crowded together (12) as to render these vertebrae less movable than vertebrae with normal discs. A hypothetical increase of mobility is counterbalanced by this mechanism.

It is also difficult to see why thinning of discs should increase the tension of ligamentous fibers, to which Schmorl and Beadle attribute the production of osteophytes. Since the distance between contiguous vertebrae diminishes as the intervening disc grows thinner, the longitudinal ligaments become loose rather than tight at this level, being then too long in proportion to the reduced space which they now bridge. Clearly a loose ligament, opposing less resistance to movements than a normal one, is less easily strained than a tight ligament which surrounds a normal disc. In support of his theory, however, Beadle points out that osteophytes—which, according to him, are the result of increased tension of ligamentous fibers—are more frequently present at the ventral than at the dorsal vertebral edges because the anterior longitudinal ligament is firmer than the posterior longitudinal ligament. He did not examine osteophytes which arise at the insertion of ligaments that are of identical strength. The lateral fibers of the longitudinal ligament are as firm on the right as on the left side. In 14 cases of unilateral thinning of discs, left or right, osteophytes and calcified fibers were found chiefly or exclusively on the side on which the distance between contiguous vertebrae was diminished (Fig. 5). Osteophytes were absent, or definitely smaller, on the opposite side, although the tension of the ligaments certainly was greater there. Similarly, in patients with S-shaped scoliosis, osteophytes and calcification or ossification of ligaments were always more pronounced on the concave side, although tension upon the ligaments is admittedly greater on the convex side.

Osteophytes may occasionally be present at the dorsal margins of the thoracic and lumbar vertebrae (2, 13), but are much more frequently found to arise from the ventral edges in these regions. In the cervical spine, however, osteophytes at the dorsal margins are quite common. In an examination of 50 unselected patients with thinning of cervical discs, no osteophytes were present in 4 cases; osteophytes were confined to the ventral edges in 9, to the dorsal edges in 10, and present on both the dorsal and ventral edges in 27 instances (Fig. 6). Since the posterior longitudinal

ligament is not stronger or firmer in the cervical spine than in other vertebral regions, the occurrence of osteophytes at the dorsal edges of cervical vertebrae in 37 out of 50 cases (74 per cent) cannot be accounted for by Beadle's theory. Moreover, in instances of disc thinning, the osteophytes are sometimes distinct from a co-existent calcification or ossification of ligaments (Fig. 6).

It follows from the above discussion that the notions gained from the study of anatomic specimens do not sufficiently account for the conditions present during life. One may arrive at a simpler comprehension by consideration of the general mechanisms involved. Bone hypertrophy—condensation and osteophytes—is never a primary reaction, but is always consecutive upon rarefaction (10). Callus cannot form, for instance, unless the fractured ends of the bone are rarefied previously. An initial traumatic rarefaction comes into play when vertebrae adjacent to a thinned disc are continually injured mechanically owing to the loss of thickness and elasticity of their natural buffer. Minute but repeated fractures occur at these vertebral edges (17). The injured vertebral bone responds by a reaction which corresponds to callus formation in other bones.

In the thoracic and lumbar vertebrae the ventral margins are more frequently and more easily traumatized than the dorsal margins, since in these regions forward flexion is a more common and less limited movement than backward extension. In the cervical spine, both the ventral and dorsal edges are exposed to trauma when the disc is thinned, since both flexion and extension are free in the neck (12). Osteophytes may fail to form when the bone does not respond by hypertrophy to the trauma (12), *e. g.*, in old age. But if the vertebral bone does respond, osteophytes arise from the ventral margins of lumbar and thoracic vertebrae, and from both margins of the cervical vertebrae, because of the mechanical conditions above set forth.

New bone is incapable of growing across normal connective fibers (10). Only in the annular area extending from the edge to the attachment of the longitudinal ligament is the vertebra devoid of a ligamentous covering. In this place, the ligament does not adhere to the vertebra, and there is an empty triangular space between the vertical vertebral surface, the inner layer of the longitudinal ligament, and the fibers which connect the latter with the disc. New bone arising from the vertebral body can grow into this space until it meets the ligamentous fibers which bound it. As the disc grows flatter, the ligament becomes looser and the triangular space larger; simultaneously, the traumatism becomes stronger and more frequent. Accordingly, the osteophytes grow larger as the disc thinning progresses.

This explanation, being in accord with

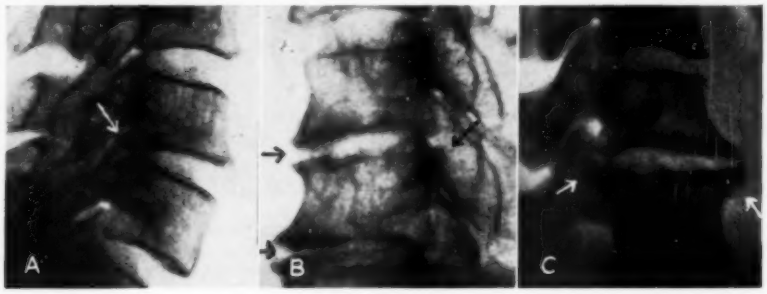

Fig. 6. In the cervical spine, osteophytes and ossification or calcification of ligaments may be confined to the dorsal borders (A) or the ventral borders or be present on both sides (B, C). Note in C the simultaneous presence of an osteophyte and ossified ligamentous fibers (white arrows), which are seen as small curved shadows projecting back of the osteophyte at the dorsal border, and in front of the osteophyte at the ventral border.

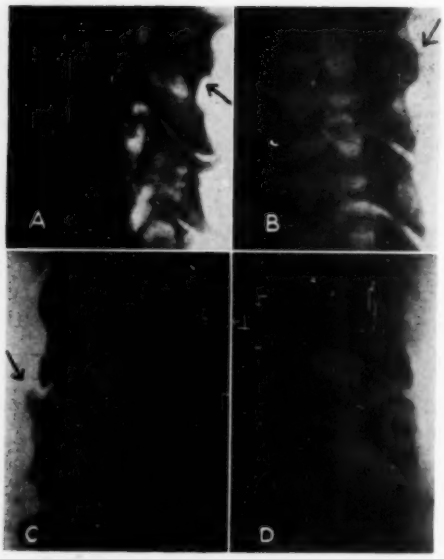

Fig. 7. A. Ossified ligamentum flavum (arrow) around a 2nd cervical apophyseal joint involved by definite arthritic lesions; note the narrowed joint space and arthritic deformity in the subjacent joint. B. Ossified ligamentum flavum in the 2nd cervical segment in the absence of arthritic changes. C. Unilateral ossification of ligamentum flavum in the cervical spine of an elderly man; opposite side (D) normal.

the facts observed both at autopsy and during life, seems to account for the formation of vertebral osteophytes—the most common lesion of the spine—more fully than notions which are based on anatomic studies only. One may say that, instead of playing an active part in the production of vertebral osteophytes, the vertebral ligaments mold them and set a limit to their growth; and it may be concluded that the vertebral ligaments play no significant rôle in the pathogenesis of the condition marked by the co-existence of osteophytes and thinned discs, variously termed osteo-arthritis of the spine, hypertrophic spondylitis, or *spondylosis deformans*.

RELATION TO LESIONS OF APOPHYSEAL JOINTS

Ossification of vertebral ligaments is common in the presence of Strümpell-Marie disease or rhizomelic spondylosis; wherefore many authors group this disease with *spondylitis ossificans ligamentosa* (8). Others, including the writer, believe that an ankylosing (atrophic, rheumatoid) arthritis of the apophyseal joints is the essential lesion (7, 9, 12, 16). The ligamenta flava, adhering to the apophyseal joint capsule, may ossify with the latter at the stage of bony ankylosis (Fig. 8). They may also form, when ossified, a bony envelope

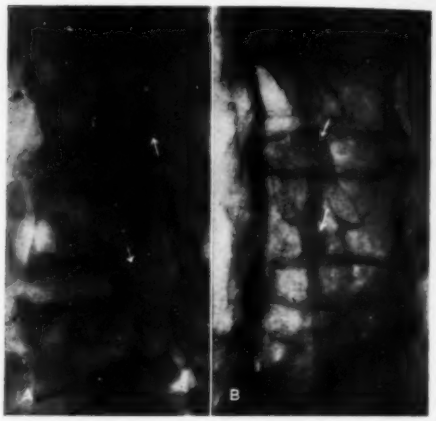

Fig. 8. Ossification of the longitudinal ligaments is a late and inconstant feature of Strümpell-Marie disease (see text). Two cases of complete rigidity of the back. A. The 2nd and 4th lumbar apophyseal joints have ragged and slightly condensed facets with narrowed joint spaces (white arrows); there is beginning ossification of the longitudinal ligament at these levels (black arrows). B. All the lumbar apophyseal joints are almost completely ankylosed (white arrows), and the ligaments are completely ossified (black arrows). In spite of the great difference in degree of the changes, the clinical manifestations were virtually identical in both cases. Compare Fig. 11.

around a joint cavity which is not yet completely ankylosed (12). The ligamentum flavum may also be found to be calcified or ossified around an apophyseal joint which is involved by a localized form of arthritis, atrophic or hypertrophic (Fig. 7), in which case the longitudinal ligament may be involved in a superjacent or subjacent segment (Fig. 12).

Examination of 50 patients with Strümpell-Marie disease (12) disclosed that the ligamenta flava were ossified in 22 cases; the interspinous ligaments in 12; and the longitudinal ligaments in 25 cases. Ossification was observed to occur not less than

fourteen months after the onset of symptoms. Similarly, in the patients with localized apophyseal arthritis, the ligamenta flava, found to be ossified in about one-half of these cases, were not involved in early stages of the disease.

These observations seem to indicate that ossification of vertebral ligaments is a late and inconstant sign in the presence of Strümpell-Marie disease and other types of apophyseal arthritis (spondylarthritis).

CALCIFICATION AND OSSIFICATION OF VERTEBRAL LIGAMENTS INDEPENDENT OF OTHER VERTEBRAL LESIONS

The longitudinal ligaments are sometimes very strongly ossified or calcified in the absence of other vertebral lesions. Of the 18 patients of this group, 17 were over fifty-five years old. There was a variable degree of general rarefaction of the vertebral bodies, as is common at this age; but there were no lesions of the intervertebral discs and apophyseal joints. There were no signs or symptoms referable to a lesion of the spine; the condition was discovered accidentally during examinations of the chest or abdomen. Calcification or ossification was most extensive in the anterior longitudinal ligament of the thoracic region, where it sometimes amounted to a kind of crest attached to the ventral surfaces of the vertebrae (Figs. 9 and 10); it was less complete in the lumbar section (Fig. 10), and absent in the cervical areas of all but 2 patients. In 6 of the cases the calcified or ossified ligament appeared to be at least twice its normal length, being very tortuous, as though it had grown too long in comparison with the bones which it connected (Fig. 9). From osteophytes the lesion is quite distinct: the intact vertebral bodies, with smooth outlines, are visible through the calcified or ossified ligaments, the latter forming an apposition often clearly separated from the bone (Fig. 9). From the ossification associated with Strümpell-Marie disease, it differs by the absence of apophyseal joint lesions and, incidentally, of any clinical manifestations (Fig. 10).

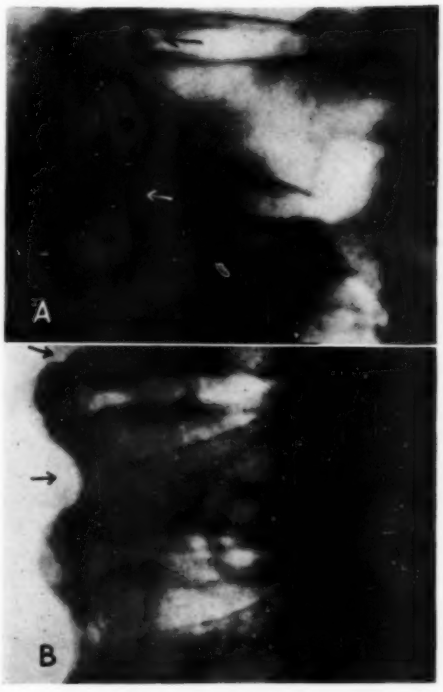

Fig. 9. Extensive ossification or calcification of the thoracic part of the anterior longitudinal ligament in two men, aged 56 and 59. Moderate diffuse rarefaction of vertebral bodies, spine otherwise normal. A. The longitudinal ligament is sometimes greatly elongated in this group of cases. No clinical manifestations. Vertebral mobility free. See also Fig. 10. B. The radiolucent interspace between the ossified ligament and the vertebral bodies (arrow) shows that the vertebral bodies are free of osteophytes.

In 7 other instances the ligamentum flavum was found to be ossified or calcified in one or two cervical segments, in the absence of other vertebral alterations (Fig. 7-C). Perhaps this was associated with an incipient or slight lesion of the corresponding apophyseal joints which was not demonstrable on roentgenographs.

The main inference from these observations is that the longitudinal ligaments may strongly ossify or calcify in elderly subjects, and that this calcification or ossification is most extensive in the regions of least vertebral mobility. Conversely, calcification or ossification was inconspicuous or absent in the cervical spine, which retains the greatest mobility throughout life.

PATHOGENESIS

The findings seem to indicate that two factors are common to the different forms of calcification and ossification of the vertebral ligaments: (1) disuse of the ligament; (2) rarefaction of vertebral bone. The observations in elderly subjects, quoted above, illustrate these points. The entire spine is slightly rarefied in these cases, but the greatest ossification or calcification of ligaments occurs in the thoracic spine, which has the least physiologic mobility, whereas the cervical spine, which is the most movable section, is rarely involved. Similarly, in the presence of senile kyphosis, when the entire spine is rarefied, the anterior common ligament calcifies or ossifies in the area in which its tension and mobility is least, namely, at the vertex of the anterior concavity. The findings also show that a ligament tends to ossify or calcify in areas in which it has grown too long, as, for instance, at the level of a reduced intervertebral space, or at the concave side of kyphotic or scoliotic regions, or when the ligament itself becomes flabby with advancing age. In the presence of inflammatory lesions of vertebral bone or joints the ligaments are set out of function owing to the immobilization which is caused by muscular guarding in incipient stages, and by synostosis or similar secondary changes in advanced phases.

Rarefaction is a fundamental reaction of bone, for the connective tissue is incapable of responding to any morbid stimulus until the mineral framework is removed. The rarefaction may be caused by trauma, infection, or metabolic disorders, and it is present in initial stages even of those conditions in which condensation eventually prevails, such as fluorine poisoning. In the presence of the infections and mechanical injuries above discussed, as well as at advanced age, rarefaction is always observed in the vertebral bodies; and in the presence of apophyseal arthritis, the articular processes are rarefied at an early stage (12). The ligaments ossify or calcify only after rarefaction begins to subside, as exemplified by the relatively late appearance of calcification or ossification after fractures, vertebral infection, and in the course of apophyseal arthritis.

The observations of Leriche and Policard (10), confirmed by British authors, show that new bone does not form until rarefaction comes to a temporary or final standstill; that new bone cannot form in normal connective fibers, but may form in fibrous tissue which has become dedifferentiated as a result of inflammation; that a certain degree of immobilization favors the transformation of dedifferentiated connective tissue into bone; and that the lime salts deposited in the new bone originate from rarefied neighboring bone. It is also known that aging or disused connective tissue undergoes calcification readily, and it is held (10) that the lime salts deposited in this tissue also have their origin in adjacent osseous substance which for some reason or other has become rarefied. Taking these results into account, one may infer from the findings recorded in this paper that the vertebral ligaments calcify in cases in which they "degenerate" owing to disuse or old age, and that they ossify in cases in which their fibers have become dedifferentiated owing to involvement in inflammation of vertebral bone. In both cases, the associated immobilization of the affected vertebral segments favors the deposition of lime salts. The latter originate from the rarefied vertebral bone.

In certain cases ossification and calcification may combine. For instance, the internal layers of longitudinal ligaments may become dedifferentiated when they take part in an inflammation of vertebral bone, such as tuberculosis (8), osteomyelitis (17), or after trauma (9), and these layers may become ossified subsequently when rarefaction subsides. The external layers in the same part may then calcify, being put out of use as a result of the ossification of the internal fibers.

In the light of present conceptions of bone pathology, the observations reported in this paper suggest that *lime salts liberated by rarefaction of vertebral bone*

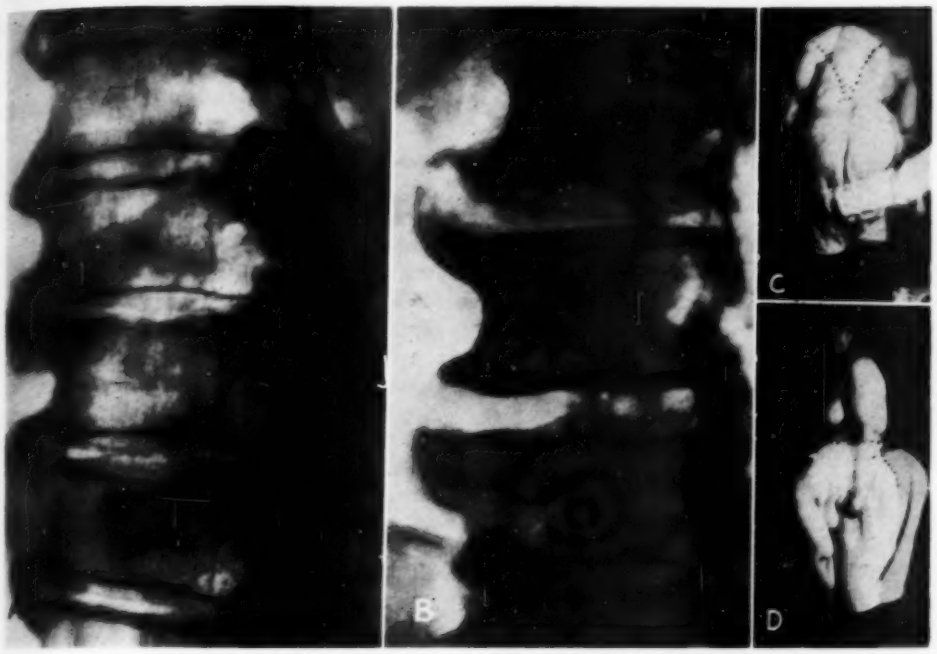

Fig. 10. Condition similar to that in Fig. 9, in a woman aged 62. The ossification or calcification is continuous in the thoracic spine (A), but incomplete in the lumbar region (B). No clinical manifestations. Vertebral movements free (C and D).

may be deposited in vertebral ligaments the tension or mobility of which is diminished.

INFLUENCE UPON VERTEBRAL MOBILITY

According to the foregoing paragraphs, the mobility of vertebral segments with ossified or calcified ligaments is diminished. But this does not always become evident on physical examination. On the contrary, comparison of roentgenographic with photographic records of vertebral movements shows that 4 cervical, 2 lumbar, and most of the thoracic vertebrae may be immovable without causing a definite limitation of the flexibility of the back or neck (12), since increased movements in adjacent segments make up for loss of mobility in the involved segments. Since the thoracic spine has scant mobility normally, ankylosis of this section is of no clinical significance. As long as the lumbar and cervical regions are sufficiently movable, calcification or ossification of the entire thoracic part of the longitudinal ligaments is compatible with perfect mobility of the back and neck (Fig. 10). When calcification or ossification has taken place in an elongated longitudinal ligament, mobility need not be limited even when the lumbar and cervical regions are involved, since in these cases the calcified or ossified ligaments may follow passively the excursions of the vertebrae (Fig. 12). It follows that immobility of a number of vertebral segments, as shown on roentgenograms made during certain movements, does not always interfere with the total mobility of the vertebral column.

Conversely, the spine may be completely stiff in the absence of any calcification or ossification of ligaments. For instance, in Strümpell-Marie disease, rigidity of the back is definite as soon as a number of apophyseal joints are involved (12) and even before they have become ankylosed; but there may be no trace of ossification of ligaments in these cases (Fig. 11). Vertebrae adjacent to an ankylosed apo-

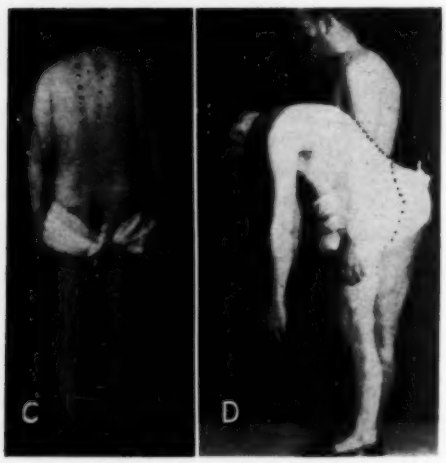

Fig. 11. Strümpell-Marie disease, in a man aged 42. Roentgenogram (A) and tracing (B) of lumbar spine show ragged surfaces and narrowed joint spaces in the apophyseal articulations, with one joint almost ankylosed (arrow), but no sign of ossification of ligaments. Sideward flexion is very much limited (C), and forward bending is achieved by means of flexion at the hip joints (D), the spine itself remaining stiff during this movement. The findings illustrated in Figs. 10 and 11 show that ossification of vertebral ligaments has no demonstrable influence upon the mobility of the spine.

physeal joint are always immovable (12), whereas vertebrae at the level of an ossified or calcified ligament may be freely movable (Fig. 12).

It may be inferred from these observations that calcification and ossification of vertebral ligaments are not the cause, but perhaps a consequence, of diminished vertebral mobility. The example of Strümpell-Marie disease shows that vertebral rigidity may precede by many years the appearance of ossification of ligaments, as mentioned above; and at advanced age the calcification or ossification is probably caused by the general decrease of mobility of the back. But it is important to remember that ossification or calcification of ligaments confined to a few vertebral segments does not usually become evident on physical examination, even when roentgenograms disclose that these segments are rendered immovable by an associated lesion of the vertebral bone or joints, since diminished mobility in one part may be compensated by increased movements of another part of the spine.

RELATION TO PAIN IN THE BACK AND TO RADICULAR MANIFESTATIONS

Since calcification or ossification of vertebral ligaments is frequently associated with, or the result of, lesions in other vertebral parts, it is not often possible to decide whether symptoms present are due to the involvement of the ligaments or of the vertebral bone or joints. The cases mentioned above (p. 167), in which calcified or ossified longitudinal ligaments were present in the absence of other vertebral lesions, are of special interest in this connection. In these 16 cases there were no clinical manifestations whatever.

In 7 patients with calcification or ossification of cervical ligamenta flava, but without lesions of other vertebral parts, pain was absent in the neck itself, but severe radicular pain was present in 2 of these instances. In a girl, aged nineteen, with persistent sciatic pain and a saddle analgesia, referred by Dr. C. Baylor, a myelogram showed a shallow filling defect at the level of the first lumbar vertebra. The tentative roentgen diagnosis of a thickened ligamentum flavum was confirmed at operation by Dr. S. Haddad. Cartilaginous and calcified foci were found in the excised ligament on histologic examination (Dr. P. F. Sahyoun[3]). The condition of the

[3] The writer thanks Dr. Baylor, Dr. Haddad, and Dr. Sahyoun for permission to publish these findings.

patient did not improve, however, and about six months later Dr. W. D. Cruikshank discovered at the ventral surface of the sacrum a tumor the size of an apple (chordoma?), which, having previously escaped searching clinical examination, was probably responsible for the radicular manifestations. Not too much weight should be given to such an isolated observation. But in view of the fact that surgical removal of a thickened or calcified ligamentum flavum has been recommended, (5, 9, 11), it may be pointed out that no control series has as yet been published to prove that such a thickened or calcified ligamentum flavum is an unusual finding responsible for clinical manifestations, and not a common and irrelevant occurrence. The case reported above shows that in the verified presence of a thickened and calcified ligamentum flavum the symptoms may be due to some other cause. Since the spatial relations between the caliber of the nerve root, the original width of the neural foramen, and the amount of its constriction by a thickened ligamentum flavum are variable, it is obvious that radicular manifestations need not be present in every case.

Fig. 12. Roentgenographic records of vertebral movements. Ankylosis of the 2nd cervical apophyseal joint (white arrow) with ossification or calcification of the longitudinal ligament in the subjacent segment (black arrow). During backward extension (A) and forward flexion (B) of the neck, the vertebrae at the level of the ankylosed apophyseal joint remain immovable, whereas the vertebrae at the level of the ossified or calcified ligament change in position. By measuring the angles formed by the horizontal vertebral surfaces (black lines) the amount of movement can be easily ascertained. The findings confirm those given in Figs. 10 and 11, showing that the mobility of the spine depends on the integrity of the apophyseal joints, but not on that of the ligaments.

The observations indicate that calcification or ossification of longitudinal ligaments does not in itself cause pain in the back or radicular manifestations. Calcified or ossified ligamenta flava may be responsible for radicular neuritis, but may also exist in the absence of clinical symptoms.

CONCLUSIONS

Cases showing roentgenologic findings of the kind above reported are usually grouped with arthritis of the spine—atrophic when the ligaments are ossified in straight layers; hypertrophic when the ossification or calcification takes place in an elongated ligament and produces bulges and "spiculations" resembling osteophytes. In the opinion of the writer, such a classification is misleading both from a clinical and from an anatomical point of view. As pointed out previously (12), the conception of arthritis applies to synovial or diarthrodial joints only, since the alterations in the synovial membranes are the incipient and essential lesions of both the atrophic and hypertrophic form. Although all types of junction of two bones, including the cranial sutures, are joints according to anatomical texts, in the spine only the apophyseal joints are true joints, i.e. synovial articulations; joints formed by the discs and the adjacent vertebral bodies are synchondroses—vertebral symphyses (12)—devoid of synovial membranes and of an articular cavity (12, 17). The ossification of the ligamenta flava which occurs in the course of an apophyseal arthritis may be considered arthritic, since the ligamentum flavum adheres to, and forms part of, the apophyseal joint capsule. But the ossification or calcification of the longitudinal ligaments around a normal or pathologic vertebral symphysis cannot be grouped with arthritis, since the symphyses are

devoid of those anatomical structures in which arthritis is localized by definition.

Clinically, the observations show that true arthritis of the spine, namely of the apophyseal joints, produces the same manifestations as arthritis of other articulations, pain and limitation of movements, no matter whether the ligaments are involved or not. But calcification or ossification of the vertebral ligaments, unless associated with apophyseal arthritis, does not induce clinical symptoms. Accordingly, ossification and calcification of vertebral ligaments conform neither to the anatomical nor to the clinical conception of arthritis.

In view of the fact that calcification or ossification of vertebral ligaments is consecutive upon many vertebral lesions without being characteristic of any particular one, it seems permissible to say that this calcification or ossification of ligaments—*spondylitis ossificans ligamentosa*—is not a distinct disease, but a secondary phenomenon. It should not be confused with arthritis. Its common appearance in vertebral segments the mobility of which has been limited for a certain period suggests that it is a record, as it were, of diminished movements of the involved part of the spine, owing either to vertebral lesions or to old age. Unless associated with an active lesion of the vertebral bodies or apophyseal joints, ossification and calcification of vertebral ligaments do not cause clinical manifestations. The presence of calcified or ossified ligaments on roentgenograms of patients suffering from backache, radicular manifestations, or both, should therefore induce the roentgenologist to search for a co-existent or underlying lesion of the vertebral bone or joints.

SUMMARY

(1) Calcification and ossification of vertebral ligaments, occurring in the course of many different vertebral lesions, are uncharacteristic reactions, not typical of any particular disease, and should not be confused with arthritis.

(2) The vertebral ligaments may calcify or ossify when, in the presence of vertebral rarefaction, their tension and mobility are diminished.

(3) The ligaments play no active part in the formation of vertebral osteophytes.

(4) In the presence of calcified or ossified ligaments vertebral mobility is normal unless the apophyseal joints or the vertebral bodies are diseased simultaneously. Complete rigidity of the spine in cases of Strümpell-Marie disease was observed to occur in the entire absence of calcification or ossification of ligaments. The ligaments ossify or calcify frequently in vertebral segments which have been immovable for some time. It is inferred that calcification or ossification of vertebral ligaments is not the cause, but sometimes the result, of diminished vertebral mobility.

(5) Immobility of a number of vertebrae, as shown on roentgenograms made during vertebral movements, does not always become evident on physical examination, since increased movements in adjacent segments may make up for the limited mobility of the involved segments.

(6) Calcification and ossification of longitudinal ligaments do not produce pain. Calcified or ossified ligamenta flava may compress nerve roots, thereby inducing radicular neuritis, but may also exist in the absence of clinical manifestations.

(7) Calcification or ossification of vertebral ligaments—*spondylitis ossificans ligamentosa*—is neither a clinical nor a pathologic entity and should not be considered an independent or distinct lesion, being usually a secondary reaction. Its presence often indicates the co-existence of a lesion of vertebral bone or joints.

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REFERENCES

1. BAKKE, S. N.: Spondylosis ossificans ligamentosa localisata. Fortschr. a. d. Geb. d. Röntgenstrahlen **53:** 411–417, 1936.

2. BAILEY, P., AND CASAMAJOR, L.: Osteo-Arthritis of the Spine as a Cause of Compression of the Cord and Its Roots. J. Nerv. & Ment. Dis. **38:** 588, 1911.

3. BEADLE, O. A.: The Intervertebral Discs. Medical Research Council Special Report Series, No. 161, London, 1931.

4. BENEKE, R.: Zur Lehre von der Spondylitis deformans. Festschrift... d. Versammelung deutsch. Naturf. und Aerzte. Braunschweig, 1897, pp. 109–131.

5. BROWN, H. A.: Enlargement of the Ligamentum Flavum: A Cause of Low-Back Pain with Sciatic Radiation. J. Bone & Joint Surg. **20:** 325–338, 1938.

6. FORESTIER, J., COLIEZ, R., AND ROBERT, P.: Etude radiologique de pièces sèches de rhumatisme vertébral. Bull. et mém. Soc. de radiol. méd. de France **23:** 612–624, 1935.

7. FRAENKEL, E.: Ueber chronische ankylosierende Wirbelsäulenversteifung. Fortschr. a. d. Geb. d. Röntgenstrahlen **7:** 62, 1903.

8. KNAGGS, R. LAWFORD: Spondylitis deformans. Brit. J. Surg. **12:** 524–546, 1925.

9. LÉRI, A.: Etudes sur les affections de la colonne vertébrale. Paris, Masson & Cie, 1926.

10. LERICHE, R., AND POLICARD, A.: Les problèmes de la physiologie normale et pathologique de l'os. Paris, Masson & Cie, 1926.

11. NAFFZIGER, H. C., INMAN, V. T., AND SAUNDERS, J. B. deC. M.: Lesions of the Intervertebral Disc and Ligamenta flava. Surg., Gynec. & Obst. **66:** 288–299, 1938.

12. OPPENHEIMER, A.: Diseases of the Apophyseal (Intervertebral) Articulations. J. Bone & Joint Surg. **20:** 285–314, 1938. The Apophyseal Intervertebral Articulations, Roentgenologically Considered. Radiology **30:** 724–740, 1938. Development and Clinical Manifestations of Ankylosing Arthritis of the Apophyseal Joints. Am. Jour. Roentgenol. In press.

13. PARKER, H. L., AND ADSON, A. W.: Compression of the Spinal Cord and of Its Roots by Hypertrophic Osteo-Arthritis. Surg., Gynec. & Obst. **41:** 1–14, 1925.

14. POLGAR, F.: Ueber interarkuelle Wirbelverkalkungen. Fortschr. a. d. Geb. d. Röntgenstrahlen **40:** 292, 1921.

15. v. ROKITANSKY, C.: Lehrbuch der pathologischen Anatomie. Wien, 1855.

16. SAUNDERS, J. B. deC. M., and INMAN, V. T.: The Intervertebral Disc: Critical and Collective Review. Internat. Abstr. Surg. **69:** 14–29, 1939 (in Surg., Gynec. & Obst., July 1939).

17. SCHMORL, G.: Die gesunde und kranke Wirbelsäule im Röntgenbild. Fortschr. a. d. Geb. d. Röntgenstrahlen, Ergänzungsband XLIII, Leipzig, Georg Thieme, 1932.

18. SIMMONDS, M.: Ueber Spondylitis deformans und ankylosierende Spondylitis. Fortschr. a. d. Geb. d. Röntgenstrahlen **7:** 51–62, 1903.

19. TURNER, H.: Quoted by Oppenheimer (12).

20. WENZEL, C.: Quoted by Oppenheimer (12).

A Universal Table for the Fluoroscopic Localization of Foreign Bodies[1]

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ROENTGEN'S discovery of the rays which bear his name was early utilized for the localization of foreign bodies. In March 1896, Buguet and Gascard (3) reported their localization method based on triangulation with a single tube-shift and published the classical formula for determining the depth of the foreign body: $X = bh/(a + b)$, where a represents the distance the tube is shifted, b the shift of the shadow of the foreign body, and h the height of the screen or plate from the focus of the tube. Most of the methods published later are based upon this formula.

The first example of wartime x-ray localization of a foreign body was recorded in 1897, when a bullet was successfully localized in the lower end of the femur of a British soldier from India.[2]

Interest in foreign body localization by means of roentgen rays was greatly stimulated during the First World War, and numerous methods were published during that period. After a long lull, interest was revived before the outbreak of the present European conflict. The great number of methods and their modifications recorded in the literature indicate, beyond doubt, that radiologists, dissatisfied with hitherto existing methods, are trying to find new ones or to improve those already in use.

In his historical review of localizing methods published in March 1918, Case (4) lists 198 papers, not including Dutch, Scandinavian, and Russian publications nor German contributions later than 1915. An accurate and perhaps complete survey of the English literature is contained in a recent paper by Reid and Black (8). In this work, which includes the analysis of 147 papers, the methods are evaluated as to their principles and suitability. Many of these methods achieve a mathematical accuracy, even from several reference points on the skin, but this is accomplished at the expense of valuable time, necessitating the use of complicated and delicate devices and intricate computations.

For military purposes in wartime only those localization methods are suitable which, having sufficient accuracy, are also rapid and easy, requiring no special devices or apparatus and involving no lengthy mathematical calculations. By "sufficient accuracy" we understand, from the point of view of war surgery, the determination of the position of the foreign body within 5 to 10 mm. Lt. Col. J. T. Case, Director of the Roentgenological Service of the A.E.F. during the First World War, wrote: "This war is not being fought with bird shot and the localization, as a rule, to 0.5 cm. will be entirely satisfactory." Major D. B. McGrigor (6) of the British army goes even further, saying: "Anything like 100 per cent accuracy is impossible, for a human body is not a motionless geometrical solid—general localization needs only to be accurate to 1 cm., except in special cases." The most important of these exceptions are foreign bodies in the eye. As such cases are transferred as quickly as possible to a special eye department, where localization with accurate methods is available (*e.g.*, Sweet's localizer), they are eliminated from further consideration in this paper.

For advanced and mobile roentgenologic stations only fluoroscopic localization

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[1] From the X-Ray Department, St. Anthony's Hospital, Rock Island, Illinois. Accepted for publication in October 1941.

[2] "Soldier from the N. W. Frontier of India 1895 had bullet wound in region of the knee—this was localized *anatomically* to metal ball fixed on skin—a method in use today—surgeons operated and found bullet quite close to the site indicated, much to the surprise of the 'X-ray officer' and surgeons." Quoted from D. B. McGrigor (7).

methods are suitable. Not only do these stations often lack equipment for roentgenography, but such procedures are time-consuming and therefore inefficient during a sudden rush of localization cases. This conclusion was reached during the First World War and fluoroscopic methods were chiefly adopted, with preference for those based on the triangulation principle with a single or double tube-shift.[3]

The French method of Strohl, the so-called "two wire double tube-shift method," was very popular in the Allied Armies. The method is described in detail in the U. S. Army *X-Ray Manual* (10) and characterized there as follows: "extremely rapid, reasonably accurate, and requires a minimum of manipulation; it is the method of preference for mobile hospitals." Even this method, however, requires a special adaptation of the x-ray unit employed, consisting of a special brass frame to be attached to the tube. The frame carries two iron or lead wires to be fixed a certain distance apart and at a certain distance from the tube-target. The reliability of the method depends entirely upon the accuracy with which the frame is made and fixed in its place.

Recently there appeared two very simple and rapid fluoroscopic devices, both based on the single-shift fixed-angle principle. The one is the "localizing profundoscope" of Reid and Black (8); the other is used with the "demountable x-ray field unit" brought into the market by an American x-ray corporation. Both methods are practicable only if certain conditions are fulfilled. Both require the use of a special scale, which must be put on the fluoroscopic screen and read during fluoroscopy or at least in the dark fluoroscopic room. In addition the "profundoscope" requires a fixed table-top distance of 30 cm. and a special cone with a vertex angle of 36°. The localization with the "field unit"—although independent of a known distance between the target and the table top or screen—is entirely dependent on its built-in special tube-shift mechanism and the special scale.

With the "field unit" it is assumed that the patient is to be examined directly on the stretcher, and no table top is provided. This procedure is, of course, justified in cases of multiple wounds with fractures or in circumstances where all unnecessary movements of the patient must be avoided. Yet in the majority of routine cases the solid table top is desirable. The localization should be performed as nearly as possible in the *surgical position*, that is the position of the patient *in which the foreign body will be removed*. Only the depth of the foreign body beneath the skin incision is of interest to the surgeon. If the patient is on a stretcher it will often be difficult to place him in the proper surgical position. Furthermore, there will be a difference in the pressure affecting the foreign body as between the pliant canvas of the stretcher and the solid board of the operating table. To quote Brailsford (2): "Once the position of the foreign body has been determined, the patient should be fixed in the position to be repeated on the operating table." But this will not always be possible because the respective referring marginal points of contact between the skin and the underlying base may not be the same on the stretcher and on the solid operating table.

In spite of the fact that both of the above mentioned methods are easy and rapid, they do not represent a general solution of the localizing problem, since they are adapted only to a special equipment and are therefore feasible only if such equipment is always available as a regulation army unit. The same may be said about any, even the most expedient, highly specialized unit which will perhaps be developed in the future.

In wartime dependence cannot be placed

[3] Maj. R. Desplats of the French Army Medical Corps (5) reported: "The experience taught us that the roentgenographic methods, the compasses, and extractions under screen should be used at the front only in exceptional cases and that a careful screen examination with an exact notation of the number and volume of the projectiles, the depth and, as far as possible, the anatomical position of those which must be found and extracted, should suffice in most cases."

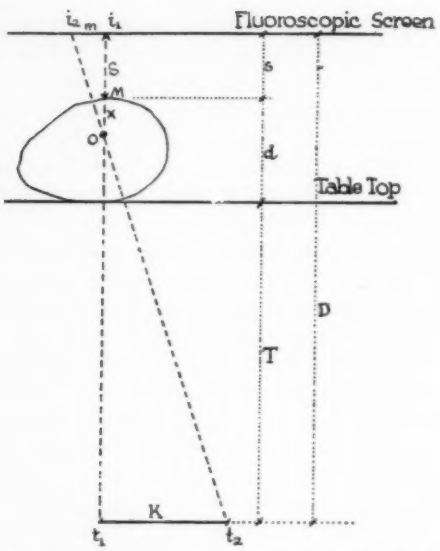


Fig. 1: Fluoroscopic localization of a foreign body.

D. Tube-target-screen distance. *S*. Skin-screen distance. *d*. Thickness of part containing foreign body. *T*. Tube-target-table-top distance. *O*. Foreign body. *M*. Vertical skin projection of foreign body. t_1. Position of x-ray tube before shift. *K*. Shift of x-ray tube. t_2. Position of x-ray tube after shift. i_1. Fluoroscopic image of foreign body from tube position t_1. i_2. Fluoroscopic image of foreign body from tube position t_2. *m*. Shift of fluoroscopic image of foreign body. *X*. Depth of foreign body beneath skin.

solely on regulation equipment—and of a single type only. Circumstances occur in which any type of equipment available in commandeered civil hospitals or in occupied enemy territory must be used.

The most desirable method, therefore, is one which, being simple, fast and reasonably accurate, is adaptable to any kind of equipment, a method which does not require particular specifications nor depend on complicated or delicate devices which could easily be damaged or lost. Furthermore, it should not require lengthy calculations, special drawings, or reading of scales in the dark fluoroscopic room. All these requirements seem to be fulfilled in the method to be described below, which, though simple and rapid, requiring no special devices or calculations, nevertheless makes possible the localization of a foreign body within a fraction of a centimeter. The method requires only that it be possible to lock the tube and the fluoroscopic screen in a certain position and again to lock the tube after a certain horizontal shift. These conditions are fulfilled in almost every horizontal fluoroscope or can easily be improvised.

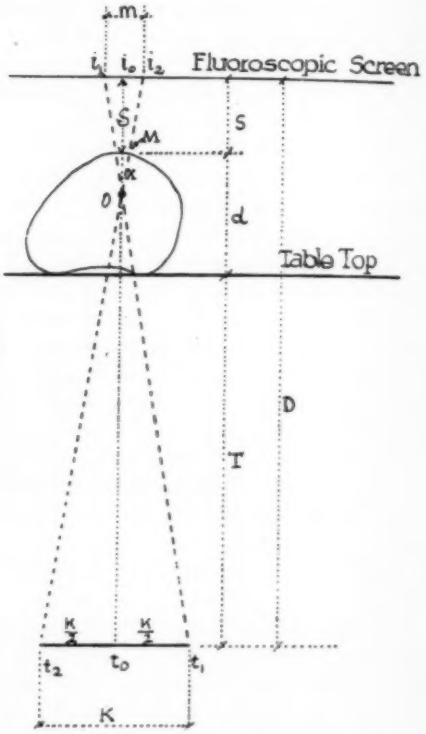


Fig. 2. Fluoroscopic localization of a foreign body.

The method is based on the fluoroscopic application of the classical triangulation principle described by Buguet and Gascard (3) and may be performed with either a single or double tube-shift, either parallel or crosswise to the long axis of the x-ray table. If the tube can be moved independently from the fluoroscopic screen, the procedure is more convenient, but the method can also be employed easily with the tube and screen moving as one unit.

The localizing procedure requires the actual measurement of just two values: (a) the thickness of the part containing the

foreign body and (b) the shift of the foreign body shadow on the fluoroscopic screen.

The geometrical basis of the method is shown in Figure 1. Because the triangles $o\ i_1\ i_2$ and $o\ t_1\ t_2$ have equal vertex angles and parallel bases, it is evident that they are similar. Therefore the following equation holds:

$$(X + S):m = D - (X + S):K \quad (1)$$

or by simplification:

$$X = \frac{mD}{K + m} - S \quad (2)$$

From Figure 1 it is also evident that

$$D = T + d + S \quad (3)$$

Hence equation (2) may be written:

$$X = \frac{m(T + d + S)}{K + m} - S \quad (4)$$

This equation holds also if a double shift is performed in two opposite directions in such a way that the sum of both shifts may equal K—for instance: $K/2 + K/2$ (see Fig. 2).

Thus far the description assumes the possibility of shifting the tube independently of the fluoroscopic screen. If, however, the tube and screen move together, the shift of the foreign body shadow appearing on the screen, m_k (see Fig. 3) will represent the sum of the tube shift K plus the true shift m of the shadow. Hence the length K has to be subtracted from the value m_k to obtain the true m upon which the localization is based.

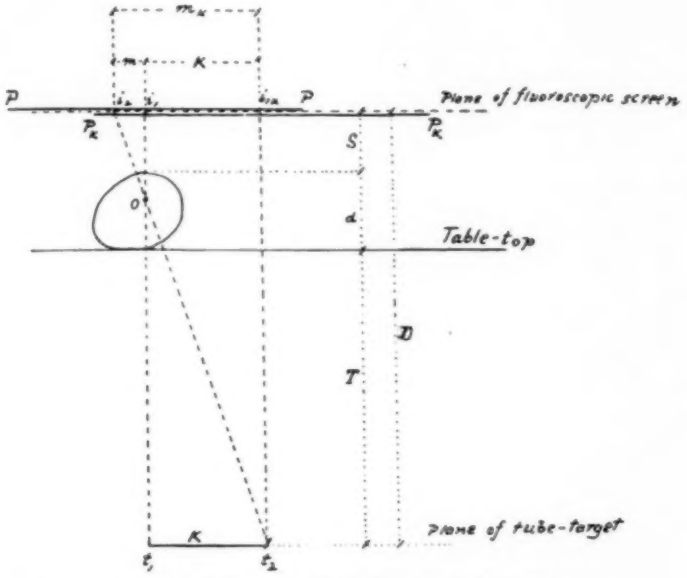
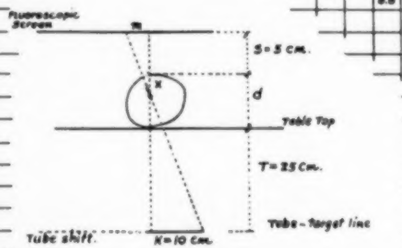


Fig. 3. Fluoroscopic localization of a foreign body. *P–P*. Position of fluoroscopic screen before the tube-shift. P_k–P_k. Position of fluoroscopic screen after joint shift of tube and screen.

The value S represents the distance between the skin and the surface of the fluoroscopic screen. The combined thickness of the screen and its lower cover is about 2 mm. and therefore has no influence whatsoever upon the final result. Nor does the thickness of the protecting lead glass covering the fluoroscopic screen on top matter, since the image of the foreign body is reproduced on the screen itself and not on the glass. If, however, a fluoroscopic (Lysholm) grid is used, its thickness must be added to the distance between the skin and the inferior surface

Table I

x = depth of foreign body in centimeters	d – thickness in centimeters of part containing the foreign body																																															x = depth of foreign body in centimeters
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	
	m – shift in centimeters of shadow of foreign body on fluoroscopic screen																																															
1	2.2	2.1	2.1	2.0	1.6	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	1
2	2.7	2.6	2.5	2.4	2.3	2.3	2.2	2.1	2.1	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2
3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	2.4	2.3	2.2	2.2	2.1	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	3
4		3.6	3.5	3.3	3.2	3.1	3.0	2.9	2.9	2.7	2.6	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	4
5			4.0	3.8	3.7	3.6	3.4	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.3	2.2	2.2	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.4	1.4	5
6				4.4	4.2	4.1	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.3	2.3	2.4	2.2	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	6
7					4.8	4.6	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.5	3.4	3.3	3.2	3.2	3.1	3.0	2.9	2.9	2.8	2.7	2.7	2.6	2.6	2.5	2.4	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.8	7
8						5.2	5.0	4.8	4.6	4.5	4.3	4.2	4.1	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.3	3.2	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.7	2.6	2.5	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.2	2.1	2.1	2.1	2.0	2.0	2.0	1.9	8
9							5.6	5.4	5.2	5.0	4.8	4.7	4.5	4.4	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.3	3.2	3.1	3.0	3.0	2.9	2.9	2.8	2.7	2.7	2.6	2.6	2.5	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.2	2.2	2.1	2.1	9
10								6.0	5.8	5.6	5.4	5.2	5.0	4.8	4.7	4.5	4.4	4.3	4.2	4.1	3.9	3.8	3.8	3.6	3.6	3.5	3.4	3.3	3.3	3.2	3.1	3.1	3.0	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.5	2.5	2.5	2.4	2.4	2.3	2.3	10
11									6.4	6.2	6.0	5.7	5.5	5.3	5.2	5.0	4.8	4.7	4.6	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.6	3.5	3.4	3.3	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.5	2.5	11
12										6.8	6.5	6.3	6.1	5.9	5.7	5.5	5.3	5.2	5.0	4.9	4.7	4.6	4.5	4.4	4.3	4.1	4.0	4.0	3.9	3.8	3.7	3.6	3.5	3.5	3.4	3.3	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.7	2.7	12
13											7.2	6.9	6.7	6.4	6.2	6.0	5.8	5.6	5.5	5.3	5.1	5.0	4.9	4.7	4.6	4.5	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.8	3.7	3.6	3.5	3.5	3.4	3.3	3.3	3.2	3.2	3.1	3.1	3.0	3.0	2.9	13
14												7.6	7.3	7.0	6.8	6.6	6.3	6.1	5.9	5.8	5.6	5.4	5.3	5.1	5.0	4.9	4.8	4.6	4.5	4.4	4.3	4.2	4.1	4.0	4.0	3.9	3.8	3.7	3.7	3.6	3.5	3.5	3.4	3.3	3.3	3.2	3.2	3.1	14
15													8.0	7.7	7.4	7.1	6.9	6.7	6.5	6.3	6.1	5.9	5.7	5.6	5.4	5.2	5.1	5.0	4.9	4.8	4.7	4.5	4.4	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.8	3.7	3.6	3.6	3.5	3.4	3.4	3.3	15
16														8.4	8.1	7.8	7.5	7.2	7.0	6.8	6.6	6.4	6.2	6.0	5.8	5.7	5.5	5.4	5.3	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.1	4.0	4.0	3.9	3.8	3.8	3.7	3.6	3.6	16
17															8.8	8.5	8.1	7.9	7.6	7.3	7.1	6.9	6.7	6.5	6.3	6.1	5.9	5.8	5.6	5.5	5.4	5.2	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.2	4.1	4.0	3.9	3.9	3.8	17
18																9.2	8.8	8.5	8.2	8.0	7.7	7.4	7.2	7.0	6.8	6.6	6.4	6.2	6.1	5.9	5.8	5.6	5.5	5.3	5.2	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	4.3	4.3	4.2	4.1	4.0	18
19																	9.6	9.2	8.9	8.6	8.3	8.0	7.7	7.5	7.3	7.1	6.9	6.7	6.5	6.3	6.2	6.0	5.9	5.7	5.6	5.5	5.3	5.2	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	4.4	4.3	19
20																		10.0	9.6	9.3	8.9	8.6	8.3	8.1	7.8	7.6	7.4	7.1	6.9	6.8	6.6	6.4	6.3	6.1	6.0	5.8	5.7	5.6	5.4	5.3	5.2	5.1	5.0	4.9	4.8	4.7	4.6	4.5	20
21																			10.4	10.0	9.6	9.3	9.0	8.7	8.4	8.1	7.9	7.6	7.4	7.2	7.0	6.8	6.7	6.5	6.3	6.2	6.0	5.9	5.8	5.7	5.5	5.4	5.3	5.2	5.1	5.0	4.9	4.8	21
22																				11.0	10.4	10.0	9.6	9.3	9.0	8.7	8.4	8.2	7.9	7.7	7.5	7.3	7.1	6.9	6.8	6.6	6.4	6.2	6.1	6.0	5.9	5.7	5.6	5.5	5.4	5.3	5.2	5.1	22
23																					11.2	10.8	10.4	10.0	9.7	9.3	9.0	8.8	8.5	8.2	8.0	7.8	7.6	7.4	7.2	7.0	6.8	6.7	6.5	6.4	6.2	6.1	6.0	5.8	5.7	5.6	5.5	5.4	23
24																						11.6	11.2	10.7	10.4	10.0	9.7	9.4	9.1	8.8	8.5	8.3	8.1	7.8	7.6	7.4	7.3	7.1	6.9	6.7	6.6	6.4	6.3	6.2	6.0	5.9	5.8	5.7	24
25																							12.0	11.5	11.1	10.7	10.3	10.0	9.7	9.4	9.1	8.8	8.6	8.3	8.1	7.9	7.7	7.5	7.3	7.1	7.0	6.8	6.7	6.5	6.4	6.3	6.1	6.0	25
26																								12.4	11.9	11.5	11.1	10.7	10.3	10.0	9.7	9.4	9.1	8.9	8.6	8.4	8.2	7.9	7.8	7.6	7.4	7.2	7.0	6.9	6.7	6.6	6.5	6.3	26
27																									12.8	12.3	11.9	11.4	11.0	10.7	10.3	10.0	9.7	9.4	9.1	8.9	8.6	8.4	8.2	8.0	7.8	7.6	7.4	7.3	7.1	7.0	6.8	6.7	27
28																										13.2	12.7	12.2	11.8	11.4	11.0	10.6	10.3	10.0	9.7	9.4	9.2	8.9	8.7	8.5	8.3	8.0	7.9	7.7	7.5	7.3	7.2	7.0	28
29																											13.6	13.1	12.6	12.1	11.7	11.3	11.0	10.7	10.3	10.0	9.7	9.4	9.2	8.9	8.7	8.5	8.3	8.1	7.9	7.7	7.6	7.4	29
30																												14.0	13.5	13.0	12.5	12.1	11.7	11.3	10.9	10.7	10.3	10.0	9.7	9.5	9.2	9.0	8.8	8.5	8.5	8.3	8.1	8.0	30



This table is based upon a distance between the tube-target and the table-top "T = 25 cm" In case of a larger T. (e.g. 30 cm.) shift the first horizontal row of figures representing the values "d"- thickness of part- to the right for as many vertical columns as amounts the difference between the actual value "T" and 25 cm, write the new values for "d" in the empty squares below the first horizontal row of figures. To avoid confusion cross off the first row of figures or cover it by a strip of adhesive tape.- Now the table can be used for the actual value "T".

Example: If T = 30 cm, write figure 3 below 8, figure 4 below 9 a. s. o.:

~~3~~	~~4~~	~~5~~	~~6~~	~~7~~	~~8~~	~~9~~	~~10~~	~~11~~	~~12~~	~~13~~	
					3	4	5	6	7	8	....

of the grid in order to obtain the true value S for the skin-screen distance.

Theoretically it would be possible to bring the fluoroscopic screen in contact with the skin and thus reduce the value S to zero. But in practice there will be many instances where this will not be possible or suitable, as (*a*) in an open wound; (*b*) where the contact of the screen causes too great pain; (*c*) if a fluoroscopic grid is used; (*d*) when the examined part is relatively thick and the foreign body lies rather close to the surface. In the latter instance the localizing procedure may be facilitated by interposition of a space S between the skin and screen. Thereby the shift m of the foreign body shadow is increased and can be more easily measured. For these reasons, and to avoid the nuisance of measuring and keeping in mind the skin-screen distance in every case, a standard value—$S = 5$ *cm.*—was adopted. This seems to be suitable for all cases. For its actual determination the most simple device is a wooden block 5 cm. thick; if a Lysholm grid is used, the thickness of the block is reduced accordingly. The block is simply to be put between the skin and screen, the screen locked in the vertical position and the block removed.

Most horizontal fluoroscopes have a tube-target-table-top distance of not less than 25 cm. This distance was chosen as a basis for working out the table which is the subject of this paper. The table is further based on the assumption that the tube shift K equals 10 cm. It is irrelevant, as mentioned above, whether a single shift of 10 cm. is performed or two shifts of 5 cm. each in opposite direction from the original position of the tube. If we insert those values in the equation (4) we obtain:

$$X = \frac{m(25 + d + 5)}{10 + m} - 5 = \frac{m(30 + d)}{10 + m} - 5$$

In this equation we can substitute successively for d (the thickness of the part containing the foreign body) different values in centimeters and, assuming always a definite value of d, again substitute successively different values for X, representing the depth of the foreign body beneath the skin. Thus it is possible to figure out in advance the value m for practically all cases and incorporate these figures in a table. Such a table (Table I) has been worked out for parts from 3 to 40 cm. in thickness, in degrees of 1 cm., and for the depth of the foreign body, also in degrees of 1 cm.

From this table it is possible to evaluate the depth of the foreign body within a fraction of 1 cm. The value m established on the fluoroscopic screen may not, for instance, be found in the column belonging to the given d; this means that the depth of the foreign body in this particular case is not expressed in whole centimeters. In such an instance the value m will lie between two figures indicating whole centimeters and its relative position between these two figures will indicate the respective fraction of a centimeter. If the value m makes just one-half of the difference between two neighboring figures, this means that the foreign body lies just halfway between two whole centimeters, hence its position is determined accurately up to a half a centimeter.

Equation (4) may also be written as follows:

$$X = \frac{m(T + d) + mS}{K + m} - S$$

This shows that the sum of the values $T + d$ is a constant. In other words, if we add to or subtract from one of these two values a certain amount—say e—and simultaneously subtract from or add to the other value the same amount, their sum will not be changed; hence the equation will still hold as follows:

$$X = \frac{m[(T - e) + (d + e)] + mS}{K + m} - S$$

$$= \frac{m(T - e + d + e) + mS}{K + m} - S$$

$$= \frac{m(T + d) + mS}{K + m} - S$$

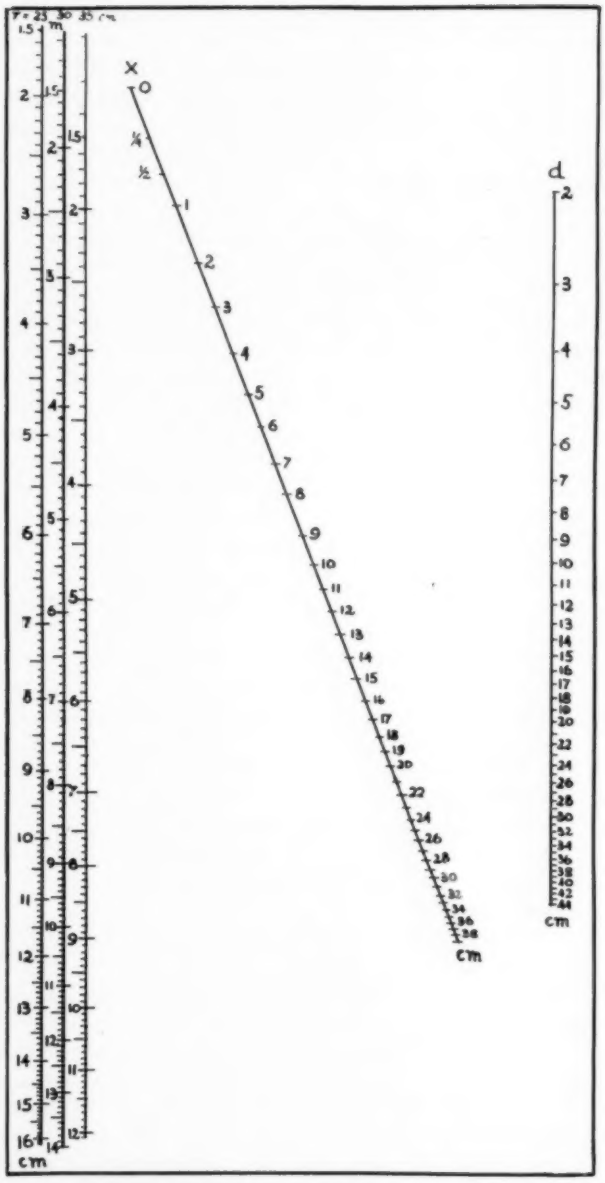


Fig. 4. Nomograph plotted for tube-shift K = 10 cm. and target-table-top distances of 25, 30, and 35 cm.

The three vertical lines on the left indicate the values of m for a target-table-top distance of 25 cm., 30 cm., and 35 cm. respectively. The vertical line on the right indicates the value of the part thickness, d. The oblique line in the center indicates the desired value X, the depth of the foreign body.

The point at which the oblique line X is intersected by a ruler placed from the value m, on the left, as found on the fluoroscopic screen, to the figure representing the thickness of the part, d, on the right, indicates the depth of the foreign body in centimeters.

It is possible, therefore, to use the table which was figured out for the target-table-top distance T = 25 cm., for any other distance. If, for instance, T equals 29 cm. and the thickness of the part containing the foreign body is 12 cm., we must subtract from T = 29 cm. the amount of 4 cm., but at the same time add 4 cm. to d (= 12 cm.). Thus we have to look for our m as measured on the fluoroscopic screen in the vertical column marked *d = 16 cm.* Likewise, using an x-ray table with T (target-table-top distance) less than 25 cm., *e.g.*, 22 cm., we should subtract from the real value d (= 12 cm.) the amount of 3 cm. and look for the measured m in the vertical column marked *d = 9 cm.* The instructions printed on Table I give a simple procedure to avoid confusion. The table contains values for d up to 50 cm. It is therefore evident that it can be used with a fluoroscope having a table-top-target distance of up to 35 cm. for parts with a d up to 40 cm.

Instead of the table a nomograph can be used. Such a nomograph was plotted for a tube-shift K = *10 cm.* and target-table-top distances of 25, 30, and 35 cm. It is reproduced as Figure 4.

With a thick part and relatively superficial location of the foreign body, where the length m on the fluoroscopic screen would still be too small for easy measurement, it may be doubled by performing instead of a single shift K, a double shift $2K$ in one direction or two shifts K in opposite directions ($K + K = 2K$). Then, of course, only the half value of the measured m has to be taken into consideration.

EVALUATION OF THE TUBE-TARGET-TABLE-TOP DISTANCE

The localizing procedure described assumes a known value T, *i.e.*, the distance between the tube-target and the table-top. Hence, it is understood that prior to localization this distance has to be evaluated. Once fixed, it remains an unchanged base for any further localization as long as the same tube or a tube of the same type (size) is used. This preparatory measurement must be performed as early as possible, before the rush of urgent work starts. To evaluate the distance by means of a yardstick is often inconvenient. A simple procedure based on the same principle as the localization itself is easier and more accurate:

The middle axis of the fluoroscopic screen, which is parallel to the tube-shift to be used for the localization, is marked by a notch on each of two opposite sides

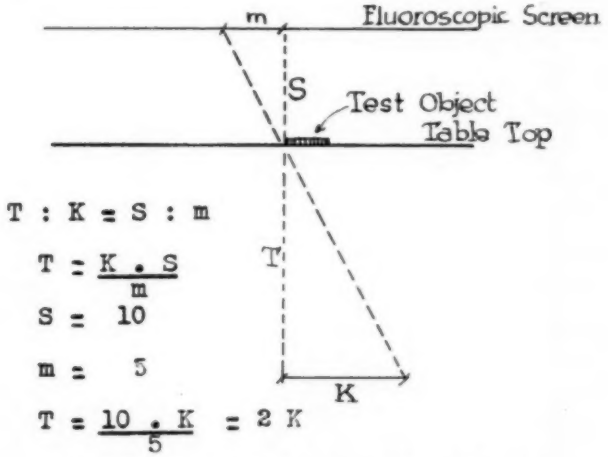


Fig. 5. Evaluation of tube-target-table-top distance.

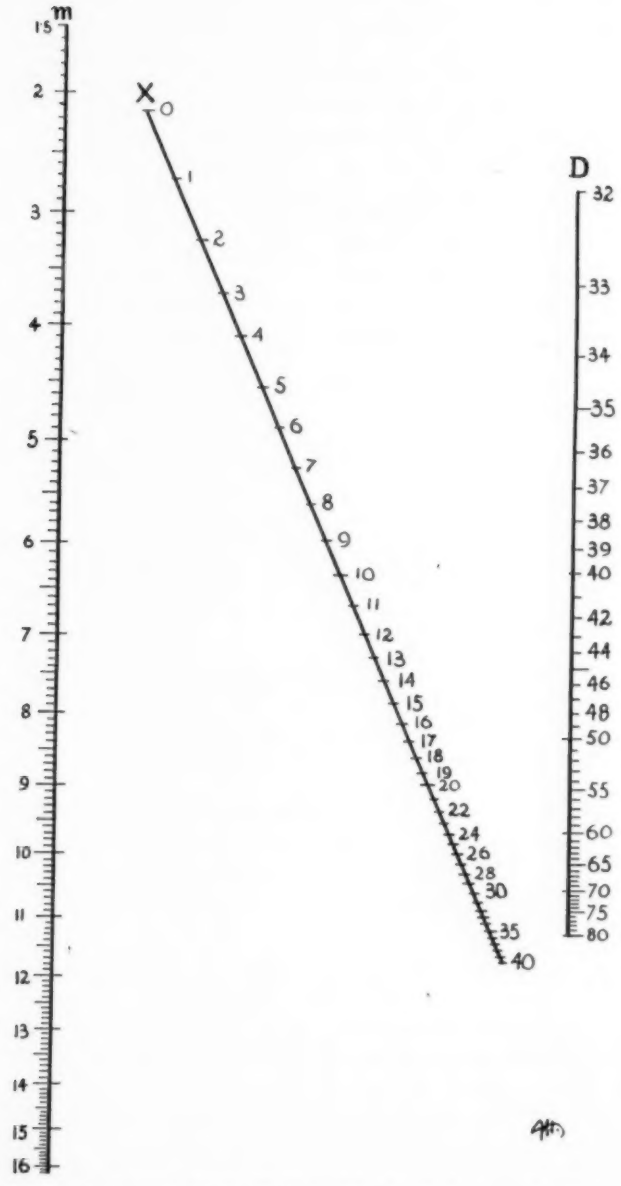


Fig. 6. Nomograph for localization of foreign body, assuming S = 5 cm. and K = 10 cm.

The vertical line on the left indicates the values of m, while the vertical line on the right indicates the distance between the tube-target and the fluoroscopic screen, D.

A ruler placed from the value m as found on the fluoroscopic screen to the point on the line D representing the target screen distance will intersect the oblique line X at a point showing the depth of the foreign body in centimeters.

of the screen frame. These notches are then joined by a line drawn on the lead glass with a skin pencil. Along this line a strip of white paper—about 20 cm. long and 4 cm. wide—is fastened by two pieces of adhesive tape. The fluoroscopic screen is now brought in a certain distance above the table-top—say 10 cm.—and a small flat metal object—a coin—is placed on the latter. With a small opening of the shutters the shadow of this object is centered on the screen and the vertical projection of one edge of the object is marked on the paper strip with an ordinary well sharpened pencil. The position of the tube is to be marked. The distance of 5 cm. is then marked on the paper strip and the tube is shifted in opposite direction until the respective edge of the test-object is vertically aligned with the new mark. The tube is to be fixed in this position and the performed shift measured. The sought distance between the tube-target and table-top is exactly twice the amount of the tube-shift. Figure 5 shows the manipulation and also the geometrical principle of the equation on which the procedure is based.

The values K and T, if $S = 10\ cm.$ and $m = 5\ cm.$, will be as follows:

K.....	12.5	13	13.5	14	14.5	15
T.....	25	26	27	28	29	30
K.....	15.5	16	16.5	17	17.5	18
T.....	31	32	33	34	35	36

In case the available horizontal fluoroscope is constructed in such a way that the tube and screen are fixed on a common pole along which the screen can be shifted vertically, it is possible to base the localization upon the target-screen distance, D, without measuring the thickness of the part d itself: This distance is easily measured by means of a stick with a metric scale attached to the pole carrying the tube and screen, the zero point indicating the level of the tube-target. With the screen placed in the proper position above the part containing the foreign body the distance $D(= T + d + S)$ is read directly. It is also possible to attach a steel tape measure to the screen carrier. From this tape the length representing the target-table-top distance is to be cut off so that with the tape pulled down from the properly placed screen until it touches the table-top the distance D can be read immediately.

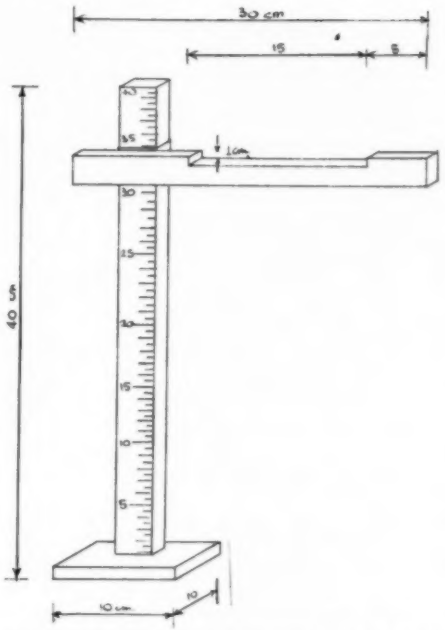


Fig. 7. Caliper devised from wooden yardstick with metric scale.

Assuming that $S = 5\ cm.$ and $K = 10\ cm.$, a nomograph can be plotted which indicates the depth of the foreign body X for various values D and m. Such a nomograph is shown in Fig. 6.

EQUIPMENT REQUIRED FOR DESCRIBED METHOD OF FOREIGN BODY LOCALIZATION

(1) *Horizontal fluoroscope*, suitable for the fixation of the tube and fluoroscopic screen in a certain position and for a repeated fixation of the tube after a horizontal shift of 10 cm. If such an appliance does not exist, the necessary simple locking devices can easily be made by any locksmith.

(2) *Wooden block*, 5 cm. thick (if a Lysholm grid is used, the block is accordingly thinner), the sides measuring 10 cm. This dimension checks the tube-shift of 10 cm. without the inconvenience of any further measurement in the dark fluoroscopic room.

(3) *Caliper*, for measurement of the thickness of the part containing the foreign body. This can be made very easily by means of a commercial wooden yardstick provided with a metric scale. See Figure 7.

(4) *Ruler*, about 15 cm. long, with a millimetric scale.

(5) *Skin pencil*, if possible blue or black to make the mark on the skin better visible in the fluoroscopic room, if illuminated by red light.

(6) *Ordinary pencil*

(7) *Ordinary writing paper*, to be cut in strips about 20 cm. long and 4 cm. wide.

(8) *Adhesive tape*

(9) *Skin marker*, which can be easily improvised: From a skin pencil cut a piece about 2 cm. long and put in a metal tube of 7 mm. in diameter, conical on one end (like a pencil cap with a tip cut off); or a piece of wire can be used which is simply wound in several coils around the pencil.

(10) *Péan forceps*, 6 to 8 inches long with a lock; serves as a holder for the skin marker.

(11 and 12) *Silver nitrate stick, and flask with photographic developer solution.* The temporary mark of the skin projection of the foreign body made, during the localization, with the skin pencil becomes permanent by painting with the silver nitrate stick moistened in the developer. The silver nitrate oxidizes immediately and leaves black indelible marks on the skin. If the skin is later disinfected for the operation with iodine, silver-iodine is formed so the mark becomes white and is very distinct against the yellow background.

Instead of No. 9 to No. 12—the standard skin inker may be used with the indelible Finzi ink, the formula of which is as follows:

Pyrogallic acid	1.0 gm.
Acetone	10.0 c.c.
Liquid chloride of iron	4.0 c.c.
Wood alcohol *q. s. ad*	20.0 c.c.

If the construction of the fluoroscope allows the use of a nomograph as described above, a steel tape measure or a metric yardstick is to be used instead of the caliper (3).

The necessary devices are all very simple and may easily be replaced in case of damage or loss.

THE LOCALIZING PROCEDURE

I. *Preliminary Action:* Evaluation of the distance between the tube-target and the table-top as described above. The established value T holds for all further localizations as long as the same tube is used or a tube of the same size.

II. *The Localization Itself:* (1) Draw a line on the fluoroscopic screen with a skin pencil, marking the axis parallel to the tube-shift, and fix a strip of paper—20 × 4 cm. along this line with adhesive tape.

(2) Decide whether the general condition of the patient will allow examination on the table-top or whether it has to be performed on the stretcher; in the latter event put the stretcher with the patient on the table-top.

(3) Make a general fluoroscopic survey to determine the number and approximate position of foreign bodies and the location of eventual fractures or other important findings.

(4) If multiple foreign bodies are present, fix and note the order in which they are to be localized. For identification of the foreign body use the anatomic region and capital letters—not figures (to avoid confusion with the thickness of the part containing the foreign body).

(5) If possible place the patient in the "surgical position."

(6) Measure the thickness of the part containing the foreign body.

(7) Lift the fluoroscopic screen above the skin to the distance S, using the wooden block. Fix the tube to this height and remove the block.

(8) On one end of the paper strip fastened on the fluoroscopic screen note the name, military rank, and detachment of the patient; the examined part; the kind of foreign body, and its identification letter if more than one are present. Further note the thickness of the part containing the foreign body. If a double tube-shift ($2K$) is used, make a distinct mark on paper.

(9) Center the tube vertically beneath the foreign body, using the smallest opening of the shutters. In case of a large foreign body align the tube with a certain margin.

(10) Note this vertical projection of the foreign body on the paper strip with an ordinary sharp pencil.

(11) Using the wooden block, fix the 10 cm. tube-shift; shift the tube with the shutters opened to a narrow slit so the foreign body may not disappear from the visual field.

(12) Close the shutters again to see the foreign body or its certain margin.

(13) Note the new projection with the pencil on the paper strip.

(14) Bring the tube back in the original position and using a small opening of the shutters mark the skin projection of the foreign body with the skin marker.

(15) Switch off the tube and mark with pieces of adhesive tape the marginal points of contact between the skin and the table-top. In case of several foreign bodies provide the adhesive tape with letters identifying each one.

(16) Remove the paper strip from the fluoroscopic screen and send it to the next room, where a clerk may in daylight measure the distance *m* between the two marks on the paper strip and find in Table I the value *X* indicating the depth of the foreign body.

(17) After all foreign bodies in an individual case have been localized the temporary skin marks are made permanent with silver nitrate.

Alternative, in case the tube and fluoroscopic screen are fixed on a common pole: Instead of performing actions Nos. 6 and 7, fix the distance *S*, measure the distance *D*, and mark it on the paper strip. In such cases the nomograph (Fig. 6) can be used.

It is understood that every case of foreign body localization must be properly reported, as described, for example, in the U. S. Army *X-Ray Manual* or in the previously quoted paper by Reid and Black.

SUMMARY

For the roentgenologic localization of foreign bodies only such methods are suitable as have sufficient accuracy and are also easy and expedient. For advanced and mobile roentgenologic stations only fluoroscopic methods are adequate.

Recently there were built several mobile x-ray field units, provided with special appliances for an expedient localization of foreign bodies. Although these units are practical, they have one common disadvantage: they will not be always and everywhere available.

A method is therefore offered which, while sufficiently accurate, is simple and rapid, requiring no computations or reading of scales in the fluoroscopic room and adaptable to any kind of horizontal fluoroscope.

This method is based upon the fluoroscopic application of the classical triangulation principle with a single or double tube-shift. A table has been prepared which makes it possible to determine the depth of a foreign body without calculation. Two nomographs serving the same purpose are also presented.

Note: The author wishes to record his thanks to Professor Zaboj Harvalik, Ph.D., St. Ambrose College, Davenport, Iowa, for plotting the nomographs.

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BIBLIOGRAPHY

1. BOWEN, D. R.: Localization of Foreign Bodies. Am. J. Roentgenol. **5:** 59–74, February 1918.
2. BRAILSFORD, J. F.: Simple Radiographic Method for the Localization of Foreign Bodies. Brit. J. Radiol. **12:** 65–75, February 1939.
3. BUGUET AND GASCARD: Détermination à l'aide des rayons X de la profondeur ou la siège d'un corps étranger dans les tissus. Compt. rend. Acad. d. sc. Paris **122:** 786, 1896.
4. CASE, J. T.: Brief History of the Development of Foreign Body Localization by Means of the X-Rays, with Bibliography. Am. J. Roentgenol. **5:** 113–124, March 1918.
5. DESPLATS, R.: Observations on Roentgenoscopy at the Front. Am. J. Roentgenol. **5:** 222–228, May 1918.
6. MCGRIGOR, D. B.: Selected Methods of Foreign Body Localization Adaptable to Radiology in Wartime. Brit. J. Radiol. **12:** 619–631, November 1939.
7. MCGRIGOR, D. B., AND WEDDELL, J. M.: Discussion on Radiology in Wartime. Proc. Roy. Soc. Med. **32:** 399–404, February 1939.
8. REID, E. K., AND BLACK, L. F.: Foreign Body Localization in Military Roentgenology. Radiology **31:** 567–583, November 1938.
9. SHEARER, J. S.: Localization of Foreign Bodies. Am. J. Roentgenol. **5:** 229–248, May 1918.
10. U. S. Army X-Ray Manual. New York, P. B. Hoeber, Inc., Ed. 2, 1932.

A New Method of Localization by a Modified Use of the Laminagraph[1]

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THE WRITER wishes to point out a rapid, simple, and practically automatic means for depth localization based on a modification of the laminagraphic principle. This method has proved practical in use for nearly three years. It is applicable to any laminagraphic instrument employing a lever with an adjustable pivot or fulcrum connecting the radiographic tube and the Bucky or plate carrier. The method is valuable both as a means for determination of the absolute depth of an object within the tissues and for presetting the instrument for inclusion of any object or structure within the plane of greatest definition preparatory to the making of a laminagram.

About the only necessary modification of the laminagraphic apparatus is the addition of a scale to the edge of the radiographic table and a pointer to the plate carrier so that any change in the position of the carrier relative to the scale can be accurately measured.

The procedure, step by step, is as follows:

1. Place patient on the table so that the tube is roughly over the expected position of the object when the tube and lever are in the mid or perpendicular position.
2. Raise the pivot or fulcrum to a point higher than the highest possible level of the object of localization, *i.e.* higher than the upper surface of the part being examined.
3. Place film in carrier and with the instrument at rest in the vertical position make an exposure just sufficient to penetrate the part.
4. With the pivot remaining at the same level, displace the tube an arbitrary distance in either direction, allowing the plate carrier to move to a new position due to the transmitted motion at the opposite end of the lever. Lock the apparatus in place and repeat the exposure on the same plate.
5. Develop the film and with calipers measure the displacement distance between the two shadows of the object on the wet film.
6. Returning to the instrument, which with the patient has remained undisturbed, loosen all locking devices except the one which holds the tube stand to its rail. Now slowly depress the pivot level while closely observing the resultant movement of the plate carrier back toward its original position. When this downward movement of the pivot has resulted in a displacement of the plate carrier equal in distance to the calipered measurement on the film, the pivot will lie in the same plane as the object of localization.

Though somewhat lengthy in detailed exposition, this method is quite simple and logical, involving but one measurement and no calculation. It is apparent that had the pivot been placed at the correct level to start with, there would have been no separation of the shadows on the film. In effect, the method is a means for forcing the shadows to coincide, thus causing the instrument correctly to adjust itself! Following the above procedure the instrument is perfectly adjusted to include the object in the plane of greatest definition if it is desired to make a laminagram.

In order for this method to prove out graphically and geometrically, it is necessary for the focal point of the tube to lie in the same horizontal plane as the axis of rotation of the tube. In practice, however, the small discrepancy in this respect found in different instruments results in negligible error.

The construction for graphic and geometric proof is as follows:

1. Locate parallel planes of movement of tube and plate carrier.
2. Indicate first and second positions of focal spot at A and B in tube plane.
3. From A drop perpendicular to plane of carrier representing the first position of the lever and on it place point P_1, first position of the pivot.
4. Locate point F, foreign body, anywhere below and lateral to P_1.
5. From B through P_1 draw line to base at L_2, representing the second position of the lever.

[1] Accepted for publication in April 1941.

6. From A draw ray through F to F_1 on base and from B to F_2 on base.

7. Locate (F_1) on base line by moving F_1 the same distance and in the same direction as L has traversed in moving to L_2 as a result of movement of tube from A to B. (It must be noted that latent image of F on film resulting from the first exposure is carried to a new position relative to the object to (F_1) as the shift is made.)

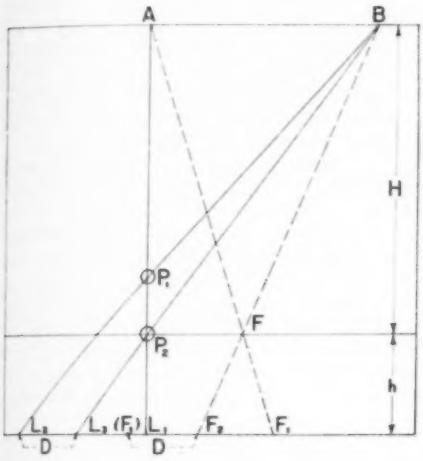
8. Measure distance $(F_1)F_2$ (which is distance of separation of the shadows on the film) and move L_2 back toward its original position through this distance to L_4.

9. Draw line from L_3 to B indicating the final position of the lever and at the intersection of this line with line L_1A locate point P_2. Draw line showing plane of P_2, which is the required position of the pivot which should coincide with the plane of the object.

10. Draw altitude H from object plane to tube plane and altitude h from object plane to base.

For the sake of clarity the space between L_2 and L_3 on the base line and likewise the space between (F_1) and F_2 have been bracketed on the drawing and marked with a D. This is to assist in showing graphically how the measured distance between the two shadows on the film is used as the correction distance in moving the lever and plate carrier to its final position at L_3.

CONSTRUCTION AND GRAPHIC DEMONSTRATION



The author is indebted to Mr. William Palm, instructor in mathematics at the University of Nevada for the following geometric proof.

Referring to the construction:

(1) L_2L_1 equals $(F_1)F_1$ by construction

(2) L_2L_3 equals $(F_1)F_2$ measured, hence

(3) L_3L_1 equals F_2F_1 by subtraction of (2) from (1).

(4) $\frac{L_3L_1}{AB}$ equals $\frac{L_1P_2}{P_2A}$ since triangle $L_3P_2L_1$ is similar to triangle AP_2B.

(5) $\frac{F_2F_1}{AB}$ equals $\frac{h}{H}$ since triangle F_2FF_1 is similar to triangle AFB.

(6) $\frac{L_3L_1}{AB}$ equals $\frac{F_2F_1}{AB}$ from (3).

(7) $\frac{L_1P_2}{P_2A}$ equals $\frac{h}{H}$ from equalities in (4), (5), and (6); therefore

(8) L_1P_2 equals h since the sum of L_1P_2 plus P_2A is equal to the sum of h plus H.

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Pancreatic Calcification[1]

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SINCE THE early description of the pancreas in 1664 by de Graaf, in his *De succi pancreatici natura et usu*, approximately 142 cases of pancreatic lithiasis have been recorded in the literature. Of these, 13 exhibited disseminated calcification. The purpose of this communication is to report an additional case of disseminated calcification, to establish certain facts concerning the rarity of the disease, and to discuss methods of diagnosis by roentgen rays.

Fig. 1. Roentgenogram showing disseminated calcification in the region of the pancreas.

CASE REPORT

F. M., white male, 49 years old, married, stone cutter by trade, had symptoms suggestive of peptic ulcer ten years before admission. Roentgenograms revealed an ulcer on the lesser curvature of the stomach. Following medical treatment symptoms were relieved, the patient gained weight, and remained well for seven years. There were no calcific shadows in the region of the pancreas in these early roentgenograms. After seven years the symptoms returned, consisting of the same type of pain and discomfort after eating that had been experienced with the first attack. On this occasion the patient was given intravenous injections of larostidin. Since he did not obtain relief, another roentgen examination was made, revealing definite disseminated calcific shadows in the region of the pancreas (Fig. 1).

The man had been a heavy consumer of alcohol for many years. On admission his chief complaints were indigestion and diarrhea, as many as ten stools being passed daily. He had shown considerable fluctuation of weight with a tendency to weight loss. At the time of reporting he is on a regular diet and is doing light work. There are intervals when he is free from symptoms. He has not had diabetes mellitus. No tests have been performed to determine the degree of pancreatic insufficiency. (This case is reported through the courtesy of Dr. William J. Davis.)

TYPES AND INCIDENCE

The pancreas may be the seat of diffuse parenchymal calcification, calculi of varying size and shape in the duct system, or both. Calculi are usually present in the head, sometimes in the body, and very occasionally in the tail of the pancreas. There may be a variety of symptoms indicative of more or less obstruction to the main ducts. Occasionally symptoms may be absent in the earlier stages of the disease. The relative frequency of the two types is indicated by the fact that but 13 instances of disseminated calcification have been previously reported.

Statistics relating to the incidence of pancreatic calcification are few. Simmonds (10) stated that he had found 15 cases among 36,000 autopsies. Moeckel (8) discovered 6 cases in 24,314 complete postmortem examinations. Five cases were encountered by Zeckwer in 10,300 hospital autopsies. Warren (11) found 3 cases in necropsies on 300 persons dying of diabetes. While these figures are enlightening, it is quite possible that many persons might be afflicted with the syndrome and never

[1] From the Surgical and Roentgenological Departments of St. Barnabas Hospital, Newark, N. J. Accepted for publication in July 1941.

reach the autopsy table. There is also the possibility that the condition may not be recognized even when roentgen examination has been adequate. As pancreatic calcification may occur at any age, abdominal roentgenograms of children should be carefully inspected. Bonnamour and Colrat (3) reported a case with onset at six years of age. The average age is around forty years (1, 4, 9). It is generally agreed that pancreatic lithiasis is found predominantly in males.

The unusual character of the syndrome and the paucity of information available in the literature should prompt the report of every such case. It is reasonable to say, therefore, from this standpoint, that the disease is rare. The burden of proof, however, is still upon us. The disease may actually exist more often than is supposed and go unrecognized either by the symptomatology or roentgen findings. Calcification probably occurs secondary to repeated attacks of pancreatitis. These usually produce symptoms referable to the gastro-intestinal tract severe enough to lead to roentgen investigation. We concluded, therefore, that if all gastro-intestinal series, gallbladder series, pyelograms, and other plates of the abdomen in one hospital covering a reasonable period of time were reexamined these might reveal any cases of pancreatic calcification provided the anatomical area of the pancreas was included in each of the various types of film and that all pancreatic concretions are sufficiently radio-opaque to register a definite shadow.

It is generally agreed that the chemical composition of pancreatic calculi is relatively constant, depending upon whether they are organic or inorganic in origin. Organic stones are made up of albuminoid substance from desquamated epithelium mixed with leucine and tyrosine, bound together with calcium (5). They have been reported to contain: fats, 12.4 per cent; fatty acids, 13.4 per cent; carbon and pigment, 40.9 per cent; cholesterol, 7.7 per cent; albumin, 3.5 per cent; phosphate, carbonate and chlorate of lime, 12.7 per cent. Inorganic stones are more common and contain, approximately: calcium carbonate, 93.14 per cent; phosphoric acid, 2.45 per cent; organic substances, 0.68 per cent; and water, 1.96 per cent. One would suspect from their chemical composition that pancreatic calculi would be largely impermeable to roentgen rays. Coste (6) reported roentgenographic studies of isolated stones compared with bones of the human finger and bladder calculi. The pancreatic concretions cast the denser shadows.

For practical purposes it may be said that any film which includes an area from the midline of the vertebrae to a parallel line two and a half inches to the right, extending from the middle of the fourth lumbar vertebra to the lower border of the twelfth thoracic vertebra, will include any disseminated calcification or calculi situated in the head of the pancreas, unless the exposures are made with the patient's left side on the table. Gastro-intestinal series, gallbladder series, flat plates of the abdomen for demonstration of the kidneys and other organs, pyelograms and other plates of the abdomen, cover the above mentioned area, and although numerous plates exposed during the usual examination of the gastro-intestinal tract show barium shadows in this critical region, those exposed before ingestion of opaque material and after evacuation are quite satisfactory.

All such pictures taken at St. Barnabas Hospital between Jan. 1, 1938, and Jan. 1, 1941, have been studied. Only one disclosed disseminated calcification of the pancreas, while 7 revealed shadows which might be considered to be calculi in the pancreatic duct system. On tracing the hospital records, the shadows in these 7 cases were proved to have been located elsewhere. The case of disseminated calcification was previously reported (2).

The findings support the assumption that pancreatic calcification is rare.

ROENTGEN DIAGNOSIS

As a result of the survey, certain deductions may be made regarding the detec-

tion of shadows in the pancreas. Most films exposed during gastro-intestinal series are worthless either because the shadow of the stomach or the colon obscures the pancreatic area, or flakes of barium in the small intestines make recognition and differentiation of calculi difficult if not impossible. It must be emphasized, therefore, that no gastro-intestinal series or roentgen investigation of the stomach should be made without first exposing a flat plate of the abdomen before administering opaque material. Likewise, before attempting to visualize the gallbladder, a plate should be exposed to encompass not only the critical area but also the corresponding area to the left of the spine. It may be said, in criticism, that since pancreatic calcification is so infrequent, additional films are unnecessary unless there is good reason to suspect the presence of calculi. While such criticism has no scientific merit, its practical aspects are also invalidated, since the detection of pancreatic pathology is not the only reason for such flat plates.

Whenever shadows are discovered in the pancreatic area, further roentgen examinations are indicated. Lateral films are important in ascertaining the position of the shadow with relation to the spine. The pancreas lies from 1 to 2 cm. in front of the spine and rarely exceeds this distance in thickness. The tail may curve posteriorly to be situated in the same plane as the bodies of the vertebrae. A large cyst or tumor of the organ must advance forward because of anatomical limitations and will encroach upon the lumen of the stomach. Inflation of the stomach with air or gas will allow this indentation to be seen in lateral and antero-posterior films. Engel and Lysholm (7) described a method of this type and in the case reported above we had the patient swallow a quantity of effervescent citro-carbonate granules and then gave him a cool carbonated beverage. Stereoscopic films are interesting and helpful if calcification is present, but they are not essential unless other tests are inconclusive. These other tests include blood amylase and lipase determinations and analysis of the pancreatic secretions recovered through an indwelling duodenal tube, both with and without the use of secretin.

SUMMARY

An additional case of disseminated calcification of the pancreas is reported, with roentgen evidence.

The incidence of pancreatic calcification is discussed and the results of the study of the roentgenograms of 754 consecutive gastro-intestinal cases are presented as evidence of the rarity of the disease.

Various features of the roentgen diagnosis of pancreatic calcification are discussed and methods are described.

REFERENCES

1. ACKMAN, F. D., AND ROSS, A.: Pancreatic Lithiasis. Surg., Gynec. & Obst. **55:** 90–95, July 1932.
2. BELING, C. A.: Calcification of the Pancreas. Am. J. Digest. Dis. **7:** 231–234, June 1940.
3. BONNAMOUR AND COLRAT: Un cas de lithiase du pancréas. Bull. Soc. méd. d'hôp. de Lyon **15:** 69–71, Oct. 7, 1919.
4. BARRON, M.: Relation of Islets of Langerhans to Diabetes, with Special Reference to Cases of Pancreatic Lithiasis. Surg., Gynec. & Obst. **31:** 437–448, November 1920.
5. BOSQ, P.: Pancreatolitiasis. Rev. sud-am. de endocrinol. **18:** 475–517, July 15, 1935.
6. COSTE, M. J.: Radiographies de calculs pancréatiques et d'un calcul biliaire en dehors de l'organisme. Lyon méd. **128:** 624–625, December 1919.
7. ENGEL, A., AND LYSHOLM, E.: New Roentgenological Method of Pancreas Examination and Its Practical Results. Acta radiol. **15:** 635–651, 1934.
8. MOECKEL: Über Pancreatica mit vier eigenen Fällen. Frankfurt. Ztschr. f. Path. **24:** 78–108, 1920.
9. SEEGER, S. J.: Pancreatic Lithiasis. Surg., Gynec. & Obst. **40:** 841–846, June 1925.
10. SIMMONDS, M.: Ueber lithiasis pancreatica. Fortschr. a. d. Geb. d. Röntgenstrahlen **30:** 81–84, January 15, 1923.
11. WARREN, S.: Pathology of Diabetes Mellitus. Philadelphia, Lea & Febiger, 1930.
12. ZECKWER, I. T.: Hypoglycemia in Diabetes Associated with Obstruction of the Pancreatic Duct. Arch. Int. Med. **54:** 330–338, September 1934.

Roentgen Dose Fractionation for Varying Periodicities[1]

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IN PREVIOUS communications (1, 2) we have presented our concept of superficial and depth dose calculations including the vagaries of the r dose with respect thereto. In the present paper we set forth our experiences with dose fractionation along with the hypothesis upon which are based the charts employed in our routine radiation therapy.

The material and cases are of the same type as referred to in our previous communications and need not be described again other than to say that for the past ten to fifteen years the fractionation method of treatment has in all *deep-seated lesions* displaced the older sub-unit method of dose application.

Three hundred and sixty-six cases treated by various methods of fractionation form the basis for this paper.

TISSUE SENSITIVITY

That there are wide variations in radiation sensitivity of different cell types, tissues, and organs is well known. Whether any greater accuracy in the listing of these structures than is encompassed in Table I is feasible remains to be determined. That there may be considerable difficulty in more accurate grading is due to the fact that sensitivity may be inherent, transient, or acquired. It varies (*a*) with the *age* not alone of the tissue but of the host; (*b*) with the *soil*, *i.e.*, character and condition of surrounding structures; (*c*) with nutrition (vascular supply and lymphatic drainage); (*d*) with physical condition both local and general. There is the further fact (*e*) that pathological processes and neoplastic disease are rarely simple, but for the most part complex, consisting of various cell types in various stages of development. In addition, tolerance and recoverability of overlying, neighboring, and deeper lying structures are limiting factors to proper and sufficient dosage to the less sensitive group of lesions.

PERIODICITY

The life cycle of cells of certain types and the optimum time for obtaining the maximum radiation effect constitute a most interesting and difficult problem, upon which the future success of radiation (in the so far unconquerable forms of cancer) may depend. To this can be added the hope that we may be at the threshold of the discovery of a means of creating an acquired, though transient, sensitivity during which radiation therapy may be made more effective.

From observations with the method of trial and error, considerable information has been acquired. From the physical standpoint we appear to be in a much better position than biologically. Nevertheless, perhaps mainly through the biologist and chemist, the clinical radiation therapist must seek further scientific support and advancement.

ROENTGEN DOSE FRACTIONATION

The theoretical considerations and the experimentation leading to the clinical adaptation of the fractional method of treatment—cumulative to the limit of tolerance of normal tissues, administered within given time periods—need hardly be reiterated here. Though the practical ap-

[1] Covering material presented in an exhibit as well as by title at the Twenty-sixth Annual Meeting of the Radiological Society of North America, Cleveland, Ohio, December 2–6, 1940. This article is a continuation of the material presented in RADIOLOGY **32:** 23, January 1939, entitled "The Co-relation of Physical and Clinical Data in Radiation Therapy." With the paper appearing in RADIOLOGY **37:** 476, October 1941, it is supplementary to and corrective of the article of January 1939, the result of continued observation and experimentation. Accepted for publication in July 1941.

TABLE I: RADIOSENSITIVITY OF NORMAL AND NEOPLASTIC TISSUE, IN APPROXIMATE ORDER

Normal Tissues	Radio-sensitivity*	Neoplastic Tissues	Broders' Grade	Duke's Classification
Lymphocytes (neutrophil and eosinophil) Lymphoid tissue Transitional cells Embryonal tissues Endothelial cells	+++ Most radiosensitive group ++	Lymphoblastoma Lymphogranuloma Lymphosarcoma Lympho-epithelioma Endothelioma Leukemia: (lymphatic; myelogenous) Embryonal carcinoma	4 Undifferentiated	C Invasive and Metastasizing
Epithelium Basal cells of skin, salivary glands, intestines Alveoli of lungs, bile ducts, and renal tubules Endothelium of young blood vessels	+ Intermediate radiosensitivity −	Embryonal renal tumor Myeloma Giant-cell tumor Epithelioma, transitional Mucoid carcinoma Hemangioma (endothelial) Medullary blastoma Pituitary adenoma	3	
Young tissues Growing cells	more ← Sensitivity → less	Well differentiated Adult type tissue		B
Adenomatous tissue Endothelium of large blood vessels Endothelium of pleura Peritoneal endothelium Nerve cells	− − Low radiosensitivity − − −	Carcinoma of uterus, rectum, thyroid, breast Epithelioma of skin (squamous), mucous membrane of bronchi Chondrosarcoma Astroblastoma Oligodendroma	2 Well differentiated	Non-Invasive
Connective tissue (old) Muscle Bone Nerve fiber	− − − − Very low radiosensitivity − − − − − −	Adenocarcinoma Osteosarcoma and fibrosarcoma Mixed type teratoma Melanoma − − − Myoma Neurofibroma − Lipoma Spongioblastoma Astrocytoma (fibrillary)	1	A

* All tissues may be said to have a given degree of sensitivity. The + − signs indicate the relative radiosensitivities. Sensitivity may be inherent, transient, or acquired.

plication of the idea was not new, the work of Regaud (3) revealed the superiority of the fractional technic over the single dose method and placed the matter upon a better footing.

The value of biological experimentation in establishing the action of radiant energy is admitted. On the other hand, finding the lethal r dose for biological material is one thing; the practical application of these observations to the complex human organism, with the necessary limitations to sublethal dosage in deep-seated lesions, is another. Uncertain as it may seem, the reaction of the elements of human skin is still the most universally understood and safest guide to radiation dosage. The skin and neighboring tissues remain the limiting factors. Thus successively through epilation, erythema, and moist desquamation to the limit of skin tolerance, as clinically observed, must the physically measured r dose be judged.

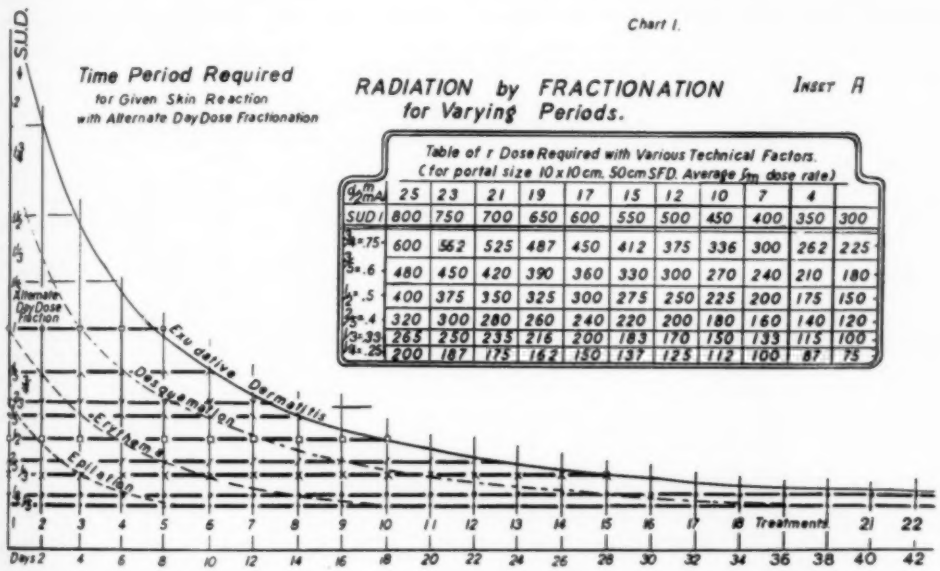
The technical problem of cumulative fractionation would seem to rest with the determination of the decadence of radiation effectiveness over a given time period. This, however, is far less simple than would at first appear. For the "vagaries" of the r dose in relation to technical variations, such as voltage and filter value, field size, dose rate, etc., we refer to our previous communications (1, 2). Herein lies another reason for substituting the skin unit dose (meaning epilation-erythema reaction) for the r dose in the first chart and table herewith presented.

In the inset in Chart 1 (inset A), we have included a table from which the r dose for any given skin unit dose, or fraction thereof, can be found, this depending upon the fixed conditions under which the particular ray quality is employed. Each vertical column is headed by the ray quality expressed in the d/2 layer (*i.e.*, half-value level) in mm. Al. The table is calibrated for a 10 × 10 cm. portal at average r/m dose rate (*i.e.*, 20 to +40 r per min.) and 50 cm. skin focus distance. Gross variation from the indicated technical factors would of course require corrections of the physically calibrated r dose. To cite a specific example: If the given radiation quality is represented by d/2 in 19 mm. Al, then the *skin unit dose* (*S.U.D.*) *is 650 r*. The various fractional doses are listed in the column below this S.U.D. These r doses may be substituted for the dose fractions appearing on the left hand side of any of the master charts here presented.

The data appearing in Chart 1, as well as in all the other charts here presented, are derived from numerous experimental calibrations and actual treatments administered, and we believe these will be found to be correct within a ±10 per cent variation. The observed reactions follow the third power rule so closely that curves are included as a guide from which some of the intermediate methods of fractionation can be derived. (Our major experience was within the 1/4, 1/3, and 1/2 dose fractionations.)

Chart 1 is based on administration of all

Chart I.



d/m/mA	25	23	21	19	17	15	12	10	7	4	
SUD	800	750	700	650	600	550	500	450	400	350	300
3/4=.75	600	562	525	487	450	412	375	336	300	262	225
3/5=.6	480	450	420	390	360	330	300	270	240	210	180
1/2=.5	400	375	350	325	300	275	250	225	200	175	150
2/5=.4	320	300	280	260	240	220	200	180	160	140	120
1/3=.33	265	250	235	216	200	183	170	150	133	115	100
1/4=.25	200	187	175	162	150	137	125	112	100	87	75

Chart 1. The multiples and fractions of the skin unit dose (S.U.D.) are indicated as alternates (in the vertical column). The elapsed time in days is indicated along the bottom of the chart (abscissae). The curves are labeled epilation, erythema, desquamation, and exudative dermatitis, respectively.

The horizontal broken lines aid in following through the indicated dose fractions appearing on the left-hand side of the chart. When on a given horizontal line, the number of treatments on alternate days, indicated by the insignia, reaches a given curve, the reaction to be expected will be indicated by that curve. The dose fraction may be translated into the required r dose for each specific quality by the use of the inset.

The inset will assist in arriving at the required number of roentgens (r) for a skin unit dose or fraction thereof, with various ray qualities. The ray quality is designated in d/2, *i.e.*, "half value" level in mm. Al, this appearing along the top horizontal line of the table. In the next horizontal line, the r dose required for a full erythema reaction appears under the respective d/2.

The vertical columns under each of the foregoing represent the r dose for fractionation. The fraction or per cent is indicated in the extreme left-hand column.

dose fractions on alternate days; similar charts for daily dosage or with two- or three-day intervals can be devised.

It is self-evident that with the larger dose fractions at short intervals, the limit of tolerance is more quickly reached, whereas when smaller dose fractions are employed, the total period of treatment is more protracted. Thus, with a 2/5 S.U.D. per application, treatments continued on alternate days will result in an exudative dermatitis in three weeks. When each single dose is 1/3 unit, given every other day, treatments will continue for fully four weeks before a similar reaction occurs. With 1/4 S.U.D. fraction, treatments may be continued six weeks. From the data in both Charts 1 and 2, the technical requirements for several periodicity variations with different fractionation are available.

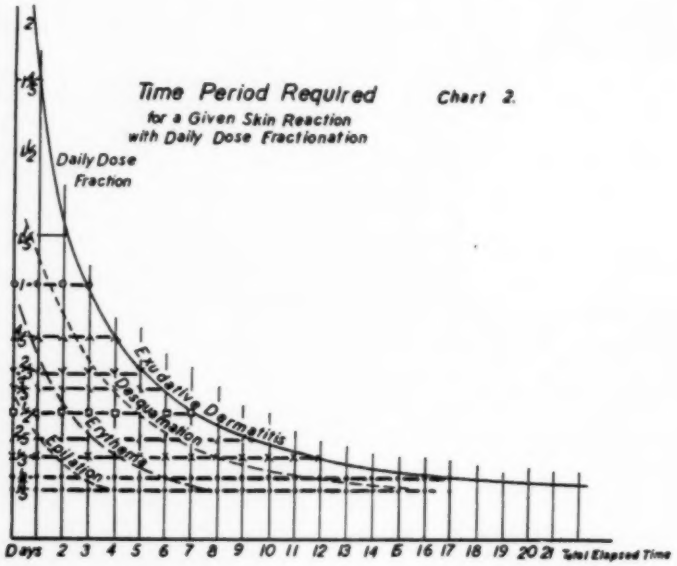

Time Period Required
for a Given Skin Reaction
with Daily Dose Fractionation
Chart 2.
Daily Dose Fraction
Exudative Dermatitis
Desquamation
Erythema
Epilation
Days 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Total Elapsed Time

Chart 2. This chart is in every respect similar to Chart 1, except that the treatments are given daily instead of on alternate days. It can otherwise be used in the same way as Chart 1. Naturally, since the time interval between treatments is shorter, the total elapsed time for a given reaction will also be shorter. Between the two charts, almost any method of dose fractionation for various periodicities can be evolved.

LIMITED PERIOD FRACTIONATION

Chart 3 has been inserted as a supplement to Charts 1 and 2, to illustrate various methods of fractionation that may be employed to reach a given reaction within a fixed time period (*i.e.* six weeks). The reactions may be somewhat different in that with heavier dosage the reaction is sharper and more of the peak type, beyond which further treatments might prove risky; whereas with the smaller fractions, below the 1/2 S.U.D., one or two more treatments could be given without exceeding the limit of skin tolerance.

It will be noted in Chart 3 that the quarter (1/4 S.U.D.) fraction is continued every other day for six weeks, as in Chart 1. The half dose (1/2 S.U.D.) is administered every fifth day, whereas an eighth dose (+1/8 S.U.D.) is given daily.

Aside from the convenience of ambulatory patients, it is a question whether any one method of fractionation indicated is superior to the others, except that with the smaller dose fractions, more frequently repeated, there is greater time latitude, affording better control by observation of

reaction. The latter is of greatest value in dealing with irritated or more sensitive body areas, such as moist skin folds or areas where adhesive plasters have recently been applied. (The sensitivity of irritated areas may be of such a degree that less than one-half the usual dosage is tolerated.)

RADIATION DOSE DECADENCE

There is such a diversity of opinion and so wide a range of variation as to radiation dose decadence that it is difficult to draw any definite conclusions.

From one source (4) comes the statement that there is as much or more than 60 per cent decadence in a day, whereas from another source, with ample background and clinical experience (5) one learns that there is but ±7 per cent daily decadence. The range is too wide to permit averaging for safe deduction when aiming at the limit of skin or tissue tolerance dosage. Admittedly difficult, it is a question how best to indicate the action and effect, decadence and cumulation of successive dose applications. The study is further complicated by the latent period between the time of dose administration and the clinically observable reaction; it becomes the more difficult when, with sublethal dosage, the processes of repair counteract the inhibitive effect and so little is microscopically discernible.

The theory of electronic disturbance within the cells leaves one in no better position to solve the problem. The idea of depositing so many roentgens (r), supplementing these with further backscatter roentgens as a tissue dose, and then by a process of dissipation deducting some of the roentgens as decadence, leaving a given dose as continued effective radiation, strikes us as bordering on the ridiculous, since, though brought about by disturbance in electronic balance, the ionometric calibration of today is but the measure of altered electrical conductivity of air and

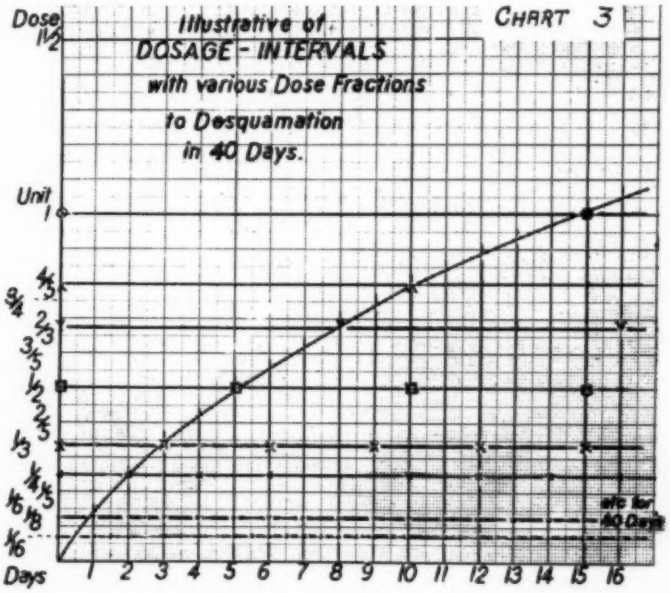


Chart 3. Illustrating the fact that a given reaction is obtainable with almost any dose fractionation, providing the proper time interval be allowed. Similar dose fractions are employed as in Charts 1 and 2. The curves on this chart and those preceding are the result of clinical observations and suggest that the dosage by fractionation closely follows the third power rule.

therefore a strictly physical measurement and not an index to tissue dose as such.[2]

Our years of experience, supported by the unchanged method of half value qualitative measurement and constant quantitative recheck by ionization, with unit, sub-unit and fractionation methods of treatment, would appear to justify the recording of our impressions as presented in Chart 4. The data here suggest that over a given lapse of time there is a greater percentage of decadence with smaller dose fractions than when larger doses are administered. This is exactly what might be expected and our experience with dose fractionation would afford the most assuring proof of the correctness of the assertion.

A further perusal of the chart reveals that whereas there is a 50 per cent decadence in a day with 1/5 S.U.D. fractions, there is only 15 per cent decadence in the same time when the full S.U.D. is given.

From the several curves on the chart the percentage of decadence for almost any period is calculable. The 50 per cent decadence period indicated by the oblique line drawn through the chart affords the most comprehensive idea of the variation of decadence with various dose fractions. It will be noted that the half period shows a range of from one day with the 1/5 dose to five days when the full S.U.D. is administered.

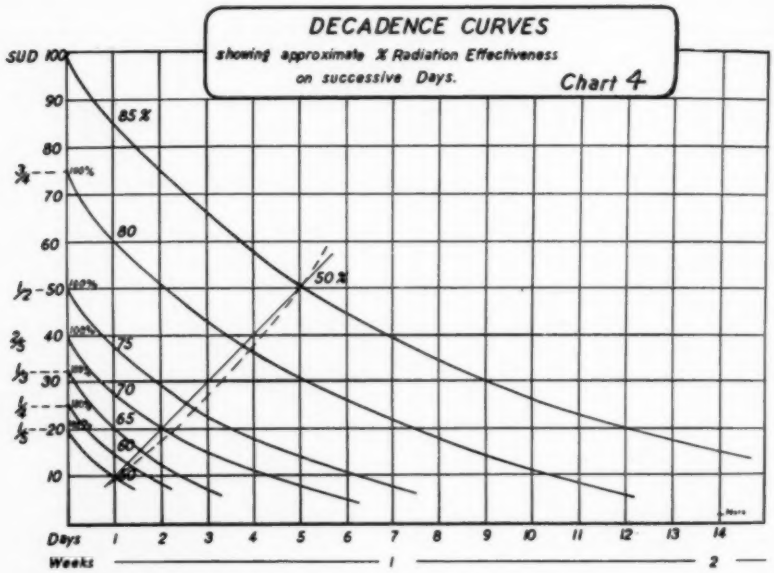


Chart 4. By means of this chart, we attempt to illustrate the percentage decadence of effective radiation on successive days. The data would indicate that the smaller the dose fraction, the more rapid the decadence. Practical experience as recorded in Charts 1 and 2 would appear to verify the conclusion at least so far as *skin reaction* is concerned in this chart.

The dose is indicated in fractions and percentage of a unit in the left-hand column. The percentage of effective radiation remaining at the end of one day is indicated in the column above the one-day lapse.

Purely for convenience, the oblique line indicates the time lapse for 50 per cent decadence for various dose fractions, whence it will be noted that there is 50 per cent decadence in one day when 1/5 S.U.D. is administered, whereas a period of five days is required for 50 per cent decadence with a full S.U.D.

[2] With the many variable factors encountered in radiation therapy practice, extending from the low voltage and weak filtration in dermatological practice to the high voltage and strong filtration of deep therapy, there is to date no definite interrelation established between the skin unit dose, the thus far observed biological reactions, and a fixed dose in roentgens.

CUMULATIVE FRACTIONATION

In Chart 5 we have attempted to illustrate the cumulative effect of radiation corrected for decadence of successively applied fractional dosage. Only the alternate-day method of treatment is here illustrated, since it is with this procedure that we have acquired our greatest experience. We believe it offers the following advantages: (*a*) a reasonable interval for recovery from systemic effect; (*b*) a greater time allowance, as treatments progress, for observation of reaction both of the skin and the lesion; (*c*) time allowance for supportive treatment, laboratory tests, blood counts, etc.; (*d*) convenience of the patient; (*e*) ability to treat a greater number of cases with limited departmental facilities. Where, because of the large number of portals, daily treatments are given, completing the round in two days, the alternate-day treatments to each area are retained.

There is probably no such continuity of reaction as would be indicated by the unbroken curves of the charts. These merely indicate the trend of maximal radiation effectiveness of the designated fraction of the S.U.D. employed. The short oblique lines leading downward represent the approximate percentage of decadence at given intervals. The intermediate parallel vertical lines represent the successive dose fractions administered. (These are shown fully in the 1/2 S.U.D. fractions and past epilation to erythema with the 1/4 S.U.D. fractionation.)

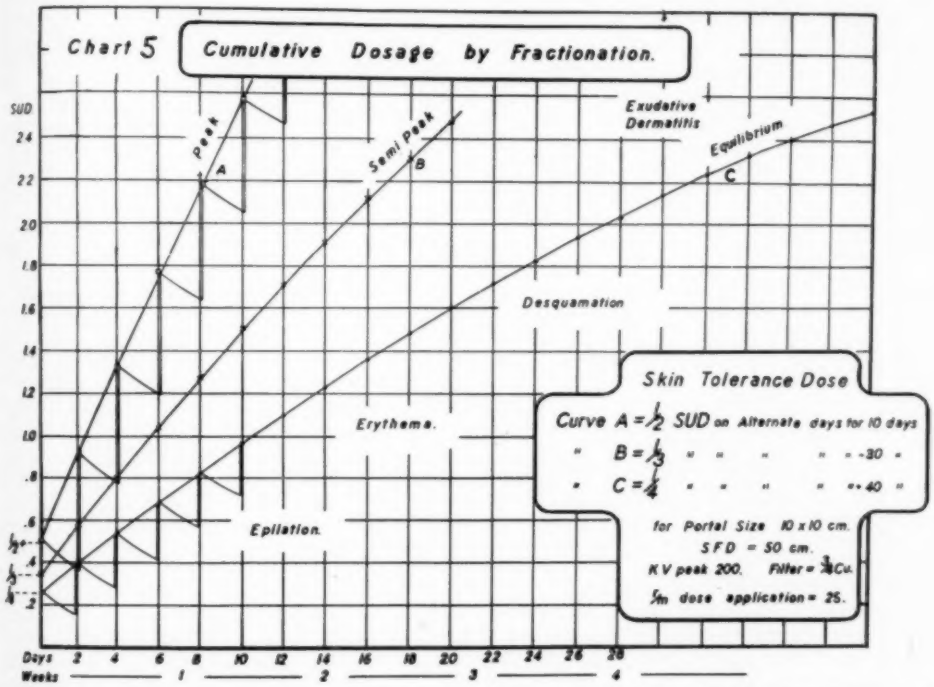


Chart 5
Cumulative Dosage by Fractionation.
SUD
Peak
A
Semi Peak
B
Exudative Dermatitis
Equilibrium
C
Desquamation
Erythema.
Epilation.
Skin Tolerance Dose
Curve A = 1/2 SUD on Alternate days for 10 days
" B = 1/3 " " " " " -30 "
" C = 1/4 " " " " " +40 "
for Portal Size 10 x 10 cm.
S F D = 50 cm.
K V peak 200. Filter = 3 mm Cu.
1/4 dose application = 25.
Days 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Weeks 1 2 3 4

Chart 5. In Chart 5, we have attempted to combine the repeated dose fraction with the percentage of daily decadence, thereby indicating the effect of cumulation of such dose fractionation. It will be noted that with repetition of the heavier dosage, the curve or line of ascent toward increasing intensities of reaction is quite steep, whereas smaller dose fractions continue over a longer period, the curve tends more to the horizontal so far as total cumulation is concerned, and the reaction is more likely to reach an equilibrium. With heavier dose fractionation, treatments beyond a given point reach a peak form of reaction and may prove serious. Smaller dose fractionation is more flexible in that a treatment or two more would not prove so serious. There is, furthermore, ample time allowance for observation of reaction.

The sharp ascent of the heavier 1/2 S.U.D. to the peak limit of skin tolerance is observed in curve A. This is in contrast to the equilibrium tolerance dose obtained with the more protracted smaller dose fractionation of 1/4 S.U.D. (curve C).

Both Chart 5 and Chart 6 are recapitulations and composites of the data presented in the previous charts and perhaps show more clearly how the various factors are applied. Chart 5 also gives an idea of when certain reactions are to be expected.

The time of cessation of treatments is also open to choice as may be indicated by the sensitivity of a given lesion. To illustrate, referring mainly to Charts 1 and 2 (providing that by proper cross-fire the same dose effectiveness at the lesion depth was obtained), with 1/4 S.U.D. fractionation two days' treatment should suffice for an ovarian castration dose. For the average lymph node tumefaction of Hodgkin's disease one week of treatment frequently results in regression. Lymphosarcomas usually require a continuation of treatment with this particular method for two to three weeks. Treatment even beyond the limit of skin tolerance is still insufficient to bring about regression of the less sensitive adenocarcinoma.

In Chart 6, we have merely illustrated another method of fractionation wherein a given dose is more rapidly attained and then maintained at equilibrium with a smaller dose fraction for a further *fixed* time, this latter depending upon the periodicity or supposed life cycle of the *cell*. The curve shown is carried only to a S.U.D. or erythema reaction, but can, of course, be lowered or raised to any reaction level desired.

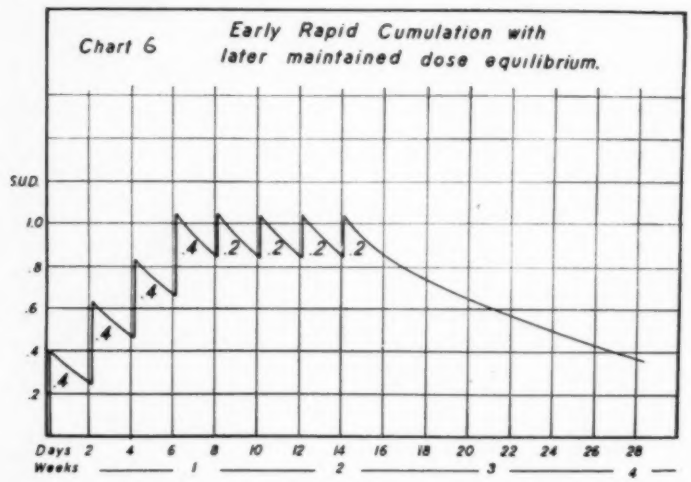


Chart 6. Method of primary heavier dose application and maintenance of reaction over a given time period with smaller dose fractions. In this particular illustration, the initial heavier dosage is administered up to an erythema reaction. Naturally, the initial dose may be carried to any one of the reactions indicated by the curves in Chart 1.

ILLUSTRATIVE CASES

The following cases are selected from a large series purely in illustration of the application of the technical factors included in this presentation. All detail excepting that with a direct bearing on radiation has been deleted.

CASE 6,789, L. K.: Extensive ulcerative fungating carcinoma of the tongue; roentgen irradiation intended as clean-up in preparation for radium implants. The method selected was 1/2 S.U.D. (= 300 r) at d/2 in 17 mm. Al, treatment being given on alternate days for ten days, cross-fire to right and left submaxillary areas directed obliquely up and mesial, but including cervical region.

After radium implantation and one month fol-

lowing discontinuance of the first x-ray series, a second series of x-ray treatments to the cervical area was begun with 1/3 S.U.D. (= 200 r) on alternate days for three and a half weeks, d/2 as above. Prognosis poor because of cervical node enlargements, probably metastatic.

CASE 6,664, H. A.: Very large inflammatory breast carcinoma selected from 225 cases of various types of breast carcinoma; proved microscopically following operation.

Roentgen irradiation was instituted preliminary to radical mastectomy, the surgeon having agreed to a six weeks' delay in operation. The procedure was as follows: 1/3 S.U.D. (= 235 r) at d/2 in 21 mm. Al; cross-fire through three portals directed obliquely: the lateral area (arm up) and the superior area (arm down) both including the axilla; the third area directed obliquely upward and outward through the breast; the three triangular-shaped areas so arranged as to cross-fire the breast thoroughly.

Treatments were continued on alternate days for twenty-two days, followed by radical mastectomy after moist desquamation ceased in the fourth week following discontinuance of treatment. Two weeks postoperatively, further irradiation was instituted, since deep extension and axillary involvement had been found to exist.

Postoperative irradiation of the thinned chest wall must be carefully instituted if pleuro-pulmonary fibrosis is to be avoided. Therefore, where direct radiation is applied to such areas, a quality of d/2 in 7 to 10 mm. Al should in our opinion not be exceeded. Under these conditions, 1/3 S.U.D. did not exceed 150 r per treatment per area.

The cervical area and axilla are cross-fired anteriorly and posteriorly. With the axillary treatments the arm is held close to the body and radiation is directed tangential to the thorax so as to minimize the depth dose effect on the lung, since on thicker parts the quality of radiation must of necessity be raised to d/2 in 15 mm. Al, or better, 1/4 S.U.D. (= +135 r) by fractionation, continued on alternate days for six weeks.

After some ten years of experience with various methods of fractionation in the different forms of deep-seated carcinoma, we are *not* yet convinced that any procedure is of proved value, so far as *cure* is concerned. A recent 5 per cent increase in the so-called five-year cures of breast cancer may as well be ascribable to case selection, *i.e.*, earlier intervention and improved operative technic as to radiation therapy.

CASE 5,155, L. A.: Lympho-epithelioma of nasopharynx, confirmed by biopsy. Radiation was administered through two lateral portals directed from the submaxillary regions upward and including the cervical areas, as well as "head on": quality d/2 in 21 mm. Al; 1/3 S.U.D. (235 r) on alternate days for ten treatments. Complete disappearance of tumor was obtained, with no recurrence during an observation period of three years. The patient is somewhat anemic but otherwise, so far, well.

CASE 750, C. S.: Mediastinal lymphosarcoma (biopsy from cervical node), selected from a total of 42 similar lesions. Radiologically this was shown to be a large mediastinal tumor (12.5 in diameter). The patient was large, and radiation was given through 4 portals directed obliquely, latero-anteriorly, and posteriorly; quality d/2 in 21 mm. Al; 1/4 S.U.D. (175 r) on alternate days for four weeks. The mass had completely disappeared after the fourth week of treatment, radiation effectiveness being noted by the end of the third week. Four years later a large tumor was palpable in the left upper quadrant (splenic). This area was similarly irradiated with disappearance of the tumor. The elapsed time since the first treatment is seven years.

CASE 6,297, P. D.: Teratoma of the testicle, diagnosed clinically in a patient 25 years old (one of 16 similar cases). Radiation therapy was followed by operative removal and microscopic study. The right testicle was said by the patient to have always been slightly larger than the left. It began to enlarge and reached the size of an orange in three months' time, when treatment was instituted. Radiation therapy was given through two opposing portals, the left testicle being protected between two spoon-shaped lead shields; quality d/2 in 10 mm. Al, 1/3 S.U.D. (150 r) on alternate days for two weeks. Radiation was also directed to the groins and paravertebral areas through right and left portals with d/2 in 27 mm. Al; 1/4 S.U.D. (200 r) on alternate days for one month. At the end of this time tumor was reduced to one and a half times the size of the opposite normal testicle. Operative removal was done and the pathologic diagnosis was mixed teratoma, with much connective tissue. It is our impression that the complete disappearance of the small embryonal type carcinoma cells was responsible for the shrinking of the tumor. Five years after treatment the patient is apparently well. Roentgenograms of the lungs are clear, with no evidence of metastasis.

It may be of interest here to remark that in 3 out of 5 similar cases, with no evidence of extension or metastasis, in which radiation therapy preceded operative removal, the patient remained well; in all other cases, where radiation therapy was applied for postoperative prophylaxis or recurrence and metastasis, death ensued.

CASE 5,388, G. M.: Lymphogranuloma, so-called abdominal Hodgkin's disease, confirmed by

biopsy from a small cervical node. Treatment was first given through 2 obliquely directed areas through the abdomen; quality d/2 in 21 mm. Al (selected because of the slimness of the patient); 1/4 S.U.D. (175 r) on alternate days for two weeks. This would total approximately 1/3 of a skin tolerance dose with a similarly proportioned depth dose at the d/2 layer (*i.e.*, 7.5 cm.).

The patient has been under observation for five years. Meanwhile occasional treatments similar to the above at d/2 in 10 mm. Al, 1/4 S.U.D. (115 r), have been given to small lymph node enlargements in the axillae and cervical areas. The patient, though somewhat anemic, is otherwise well and working as an aviation mechanic.

Exclusive of the acute, febrile cases and those with other complicating conditions, we have in a similar manner treated 146 cases of Hodgkin's disease over periods ranging from four to twelve years. A few patients died in the acute terminal stages of the disease. The majority that we successfully followed succumbed to intercurrent infections, the most frequent of which was pneumonia, usually at a time when the latter disease was most prevalent.

In the cases here presented we have deliberately abstracted mainly those parts of the records that have to do with the fractionation dose method and quality of radiation employed, further technical details having been omitted. This is not the place for discussion of the general or special care of patients, important as this is.

Modifications of treatment will depend upon the condition of the patient; thus toxicity, acuity, febrile reaction as well as a declining white blood count or impairment of renal function will necessitate marked curtailment of treatment if a rapid exitus is to be avoided. This simply means that in our desire for technical accuracy, we must never lay aside our medical training. Any diagnostic or therapeutic procedure that endangers the well being or life of the patient is bad practice.

SUMMARY

1. In applying any system of radiation therapy, the relative radiosensitivity of different tissues and lesions is of primary consideration.

2. The correlation of tissue sensitivity with some observable human reaction is essential. Lacking any other satisfactory biological standard, the skin reaction to radiation remains the best available.

3. The factors responsible for the inconsistencies of the r dose include not alone voltage and filter variations, but also the size of the area irradiated as well as the dose intensity or time factor (r/m). In this article, a continuation of two previously published, the subject of treatment by dose fractionation is the main topic under consideration.

4. The variations for the skin unit dose (S.U.D.) are incorporated in Inset A, Chart 1. If one includes the available information on supervoltage radiation, then this r dose varies from less than 300 r at 50 kv. to 1,000 r at a million volts and *strong filtration*.

5. When dosage is applied by fractionation over a long period, the subject of interval tissue recovery or dose decadence must receive consideration. Our clinical and experimental conclusions have been incorporated in three charts, wherein a wide variation of the time factor as well as the total r dose administered depends upon the dose fraction and the frequency of repetition in producing any given action. The charts include time variations of from 1 to 6 weeks, which should suffice for average periodicity variations.

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REFERENCES

1. MEYER, WM. H.: Co-relation of Physical and Clinical Data in Radiation Therapy. Radiology **32:** 23–45, January 1939. Bibliography.

2. MEYER, WM. H.: Depth Dose Calculation. Radiology **37:** 476–486, October 1941.

3. FERROUX, R., REGAUD, C., AND SAMSSONOW, N.: Comparaison des effets produits sur les testicules du lapin, au point de vue de la stérilisation de l'épithélium séminal, par une même dose de rayons X, selon qu'elle a été administrée sans fractionnement ou bien fractionée et étalée dans le temps, Compt. rend. Soc. de biol. **128:** 173–176, 1938.

4. MACCOMB, W. S., AND QUIMBY, E. H.: Rate of Recovery of Human Skin from Effects of Hard or Soft Roentgen Rays or Gamma Rays. Radiology **27:** 196–207, August 1936.

5. PFAHLER, G.: Saturation Method in Roentgentherapy as Applied to Deep-Seated Malignant Disease. Brit. J. Radiol. **31:** 45–58, February 1926.

Temperature and Radiosensitivity of Skin of New-Born Rats

IV. Effects of Decreased Circulation and Breathing during Irradiation[1]

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FOR MANY YEARS occasional reports have appeared in clinical and experimental literature suggesting the possibility of increasing or decreasing the amount of injury produced by a given dosage of roentgen radiation by controlling the metabolic rate of the cells. These reports have usually suffered from one or more of the following difficulties: lack of adequate control of the metabolic rate of the biologic material; lack of careful and quantitative analysis of the results; difficulty of applying conclusions derived from the study of the lower animals to mammalian tissue.

An attempt has been made to answer the above objections by using mammalian tissue (skin of new-born rats), the metabolic rate of which responds rapidly to changes in environmental temperature and which is relatively sensitive to roentgen radiation. It was found in the first investigation (1) that the radioresistance of the skin of new-born rats was greatly increased by chilling the animals to or near 0° C. during the irradiation. A method of measuring the radiation injury was devised (2), and it was found that for the cold-treated animals the threshold dosage was raised and that above this point the injury increased less rapidly with increased dosage than it did in animals irradiated at room temperature. In the third investigation (3) new-born rats were irradiated at temperatures ranging from 0 to 40° C., and it was found that the radiosensitivity increased in proportion to the rise in temperature. The purpose of the present investigation was to determine whether the temperature could have acted through its control of such metabolic processes as rate of blood circulation and breathing. This was done by lowering the metabolic rate by means other than low temperature.

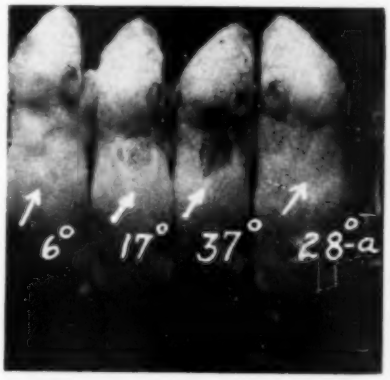

Fig. 1. Four litter mates, two weeks after an irradiation through a 4 × 9 mm. port. The temperatures of the animals during the irradiation were as indicated and the region treated is shown by the arrow. The animal at the extreme right was irradiated at 28° C. but was taped so tightly that its breathing was temporarily blocked.

The exposure time in all experiments was fifteen minutes and the dosage was 2,010 roentgens. The target distance was 30 cm. The radiation was unfiltered, except for 2-mm. cardboard, and the half value layer was about 1.5 mm. aluminum.

EFFECT OF REDUCED BREATHING RATE DURING IRRADIATION ON RELATIVE RADIOSENSITIVITY

It was found that a new-born rat could be taped so tightly that it could not breathe, and could be revived after fifteen to twenty minutes of this treatment. A condition approaching anoxia was produced and this greatly increased the radio-

[1] Aided by grants from the Committee on Radiations of the National Research Council and the Rockefeller Fund for Research on Physiology of the Cell.

The writers are indebted to Professors H. D. Kerr and J. H. Bodine for their interest and helpful criticism, and to Professor E. Witschi, who supplied the animals from his rat colony.

Paper accepted for publication in July 1941.

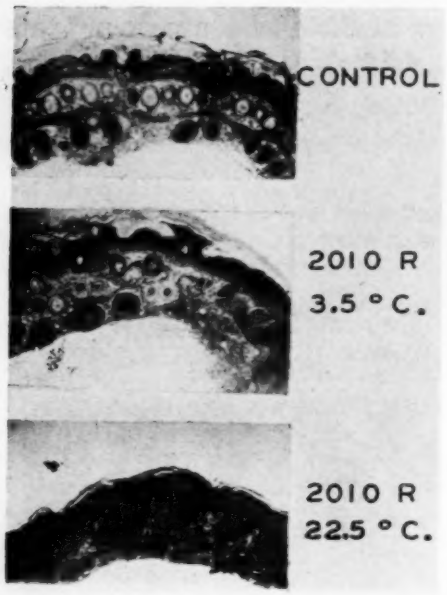

Fig. 2. Cross-sections of skin from the tail of animals two weeks after irradiation. Note that the injury of the skin irradiated at 22.5° is much more marked than that treated at 3.5° C.

resistance of the skin, as can be seen in Fig. 1. The resistance, as indicated by failure of the radiation to produce epilation, was about the same as that of the rat irradiated at 6° C. and was greater than that of the one treated at 17° (breathing rate reduced but not completely stopped). Histologic examination of the skin irradiated while the breathing was blocked indicated that the injury corresponded to that of only 900 roentgens to animals irradiated at 28° C. while breathing freely. The experiment was repeated, and again the animal whose breathing was blocked during irradiation proved to be very radioresistant.

EFFECT OF REDUCED CIRCULATION DURING IRRADIATION ON RELATIVE RADIOSENSITIVITY

The Tail: It is advantageous in studying the effect of ligation to use the skin of extremities instead of that of the body. A preliminary experiment was done to make certain that the radiosensitivity of the skin of the tail would be decreased by low

Fig. 3. Animals two weeks after irradiation. The tail of No. 1 was irradiated with the circulation blocked by means of a ligature. The tail of No. 2 was ligated but not irradiated. The tail of No. 3 was irradiated, with unimpaired circulation.

temperature. The tail of a new-born rat was irradiated while packed in ice and the resultant injury was much less than that of the tail of a litter-mate irradiated at room temperature (22.5° C). These effects on the skin of the tail are shown in Figure 2.

In the next experiment the tails of two animals were irradiated at room temperature, but in one the circulation was blocked by means of a ligature around the base of the tail. The ligature was allowed to remain in place for ten minutes before irradiation was begun. It can be seen from Figure 3 that the tail irradiated with circulation blocked (animal No. 1) was less injured than that treated with the circulation unimpaired (No. 3). The control tail (No. 2) was ligated for thirty minutes (no irradiation) and showed no ill effects when examined two weeks later. The tissue injury produced by the radiation under the two conditions is shown in Figure 4. The appearance of the skin of the tail irradiated with circulation blocked is similar to that of untreated tails, whereas in the skin of the tail with normal circulation, radiation produced extreme epilation, injury to the epidermis, and fibrosis.

The Foot: Circulation in the foot was retarded by tying a rubber band tightly around the shank. We shall describe, briefly, two experiments with two-day-old animals, one with four-day-old rats, and one with animals twelve days of age.

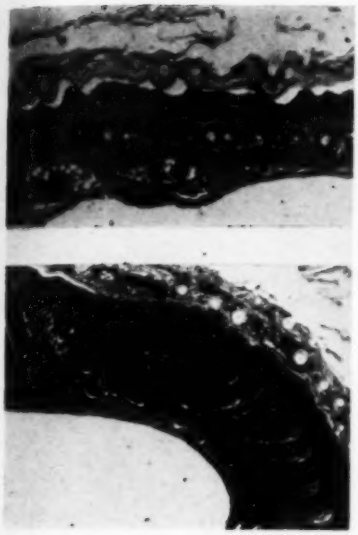

Fig. 4. Photomicrographs of the skin of the irradiated tails shown in Fig. 3. The skin irradiated with the ligature in place (upper photograph) shows very little injury, whereas the skin of the tail irradiated with normal circulation (lower photograph) shows complete epilation, extreme fibrosis, and swelling of the epidermis.

Experiment 5 (age 2 days): Four rats were used in this experiment. Both hind legs of animals No. 1 and No. 3 were ligated for twenty-five minutes. One foot of each animal was irradiated beginning ten minutes after application of the ligature. The other foot in each case served as a control. The legs of rats No. 2 and No. 4 were not ligated, and one foot of each was irradiated at the same temperature as above (25° C.). On examination eleven days later the radiation injury was much more apparent in rats No. 2 (Fig. 5-E) and No. 4 (5-D) than in animals No. 1 (5-C) and No. 3 (5-B). The injury to the feet with circulation blocked during irradiation consisted of partial epilation, slight edema, and malformation of the toes, while the feet of rats No. 2 and No. 4 showed complete epilation, extreme hyperplasia of the epidermis, and necrosis of the toes. In the controls (both ligated and not ligated) the feet were apparently normal in all respects.

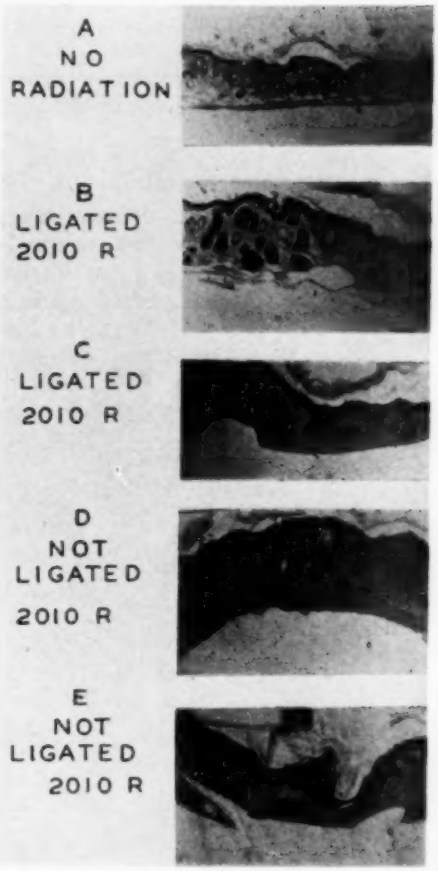

Fig. 5. Photomicrographs of the dorsal skin of the feet eleven days after irradiation. Note the marked injury of *D* and *E* as compared with *B* and *C*.

Experiment 7 (age 2 days): This experiment had two objects: (1) to determine whether ligation of seventy-five minutes would increase the radioresistance of the skin more than ligation limited to thirty minutes; (2) to determine whether low temperature would increase the radioresistance of the skin of the foot. Typical sections of the irradiated skin are shown in Figure 6. One hind leg of each rat was not irradiated and served as a control. In all of these controls (even the one ligated for seventy-five minutes) the skin was uninjured when examined two weeks later. It was concluded from the results that the foot ligated for seventy-five minutes was

no more resistant to the radiation than the one ligated for thirty minutes. It is also apparent that the low temperature greatly increased the radioresistance of the skin of the foot.

Experiment 2 (age 4 days): Three animals were used in this experiment. The external appearance of the feet twelve days after the irradiation is shown in Figure 7. The irradiated leg of rat No. 1 was ligated during the treatment and it can be seen that the injury is much more mild than that of the irradiated foot of rat No. 2, which was not ligated. Animal No. 3 was the control. Microscopic examination of the skin revealed only slight epilation in No. 1, while rat No. 2 showed extensive hyperplasia of the epidermis, complete epilation, and many areas of ulceration.

Experiment 6 (age 12 days): In animal No. 1 both hind legs were ligated for thirty minutes, and the left was irradiated. When examined eight days later the irradiated foot showed some epilation externally, but microscopic study revealed the presence of many hair follicles. There were no other signs of injury.

In animal No. 2 neither foot was ligated; the left was irradiated. Radiation produced complete epilation and ulceration. In places the epidermis was entirely missing and the entire section of skin showed necrosis.

In animal No. 3 both hind legs were irradiated, with the left one ligated. The radiation produced severe injury to the skin of the leg not ligated during the treatment, whereas that produced in the skin of the ligated one was very mild

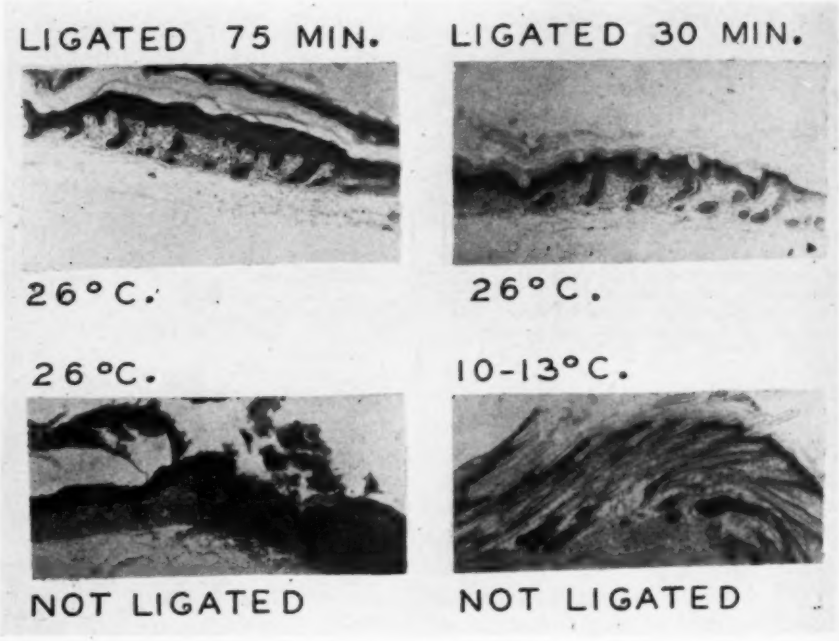

Fig. 6. Photomicrographs of the dorsal skin of the feet two weeks after irradiation. Note that the skin of the foot irradiated at 26° with normal circulation shows extreme injury (ulceration, etc.), that the skins irradiated at 26° while ligated show only slight injury, and that the skin of the foot irradiated cold shows no injury at all.

EFFECT OF LOW TEMPERATURE ON RADIOSENSITIVITY OF OLDER ANIMALS

We were successful in our only attempt to chill an older rat, although some difficulty was experienced in reviving it. The rat was twelve days old and its body

TABLE I: EFFECT OF LOW TEMPERATURES IN OLDER ANIMALS
(Animal No. 1 Irradiated at 0°C. Nos. 2 and 3 Irradiated at Room Temperature.)

Time After Irradiation	Animal Number	Condition of Irradiated Regions	
		Ventral	Dorsal
5 days	1	Slight epilation	No epilation
	2 & 3	Much epilation	Partial epilation
9 days	1	Complete epilation No ulceration	Partial epilation
	2 & 3	Complete epilation Areas of ulceration	Complete epilation
20 days	1	Completely covered with new hair	Partial epilation No new hair
	2 & 3	Ulcerated areas healed No new hair	Some new hair

was well covered with hair. The body temperature (as measured by a thermocouple on the skin) changed slowly for the first few minutes, and then dropped rapidly to 2.7° C., at which temperature no heart beat nor breathing movements were visible. After the irradiation the body temperature had dropped to 0° C. The changes (following irradiation) in the skin of this animal, and two of its litter mates irradiated at room temperature, are summarized in Table I.

The microscopic study indicated slight injury to the skin of the animal irradiated at 0°, whereas that of the two irradiated at room temperature showed epilation, fibrosis, and injury to the epidermis. It was quite evident that the low temperature had increased the radioresistance of the skin.

DISCUSSION

It is evident from the preceding data that the action of low temperature in increasing the resistance of the skin of newborn and older rats to roentgen radiation can be due to its retarding action on the metabolic rate.

The "fluid flow" theory of Failla (4, 5) and the supporting data of Failla and Sugiura (6) and Sugiura (7, 8) emphasize the importance of the environment of mammalian tissue cells *subsequent* to radiation treatment. Our data indicate that environmental factors during irradiation affect the degree of injury produced in growing mammalian skin. It is indicated that the metabolic rate has a more fundamental rôle than has been supposed. It is not probable that it would influence the ionization produced by the radiation but it might possibly affect the processes of recombination of ions and the activation and denaturation of molecules.

Fig. 7. The leg of No. 1 was irradiated while ligated; No. 2 was not ligated while irradiated; and No. 3 was not ligated and not irradiated.

Aside from the theoretical considerations, the effects obtained by changing the environmental conditions offer some hope of increasing the tissue tolerance-tumor tolerance ratio. It may prove possible, by lowering the metabolism of normal tissues and increasing that of tumors, to enhance the therapeutic action of roentgen radiation. It must be borne in mind, however, that if the agents used to change the metabolic rate are in themselves harmful

the results might be quite different. Preliminary data indicate that low temperature before (room temperature during) and after the irradiation does not decrease, and possibly even increases, the radiosensitivity of the skin of new-born rats. This problem is being investigated at the present time.

SUMMARY AND CONCLUSIONS

New-born rats have been irradiated under conditions in which the metabolic rate is lowered. Mechanically retarded breathing, ligation, and cold treatment were utilized. In all cases the lowered metabolic rate increased the radioresistance of the skin.

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REFERENCES

1. EVANS, T. C.: Effects of Roentgen Radiation at Low Temperature on the Skin of Young Rats. Am. J. Roentgenol. **45:** 888–894, June 1941.

2. EVANS, T. C., ROBBIE, W. A., GOODRICH J. P., AND SLAUGHTER J. C.: Low Temperature and Radiosensitivity of Skin of New-Born Rats. II. Resistance at Different Dosages. Proc. Soc. Exper. Biol. & Med. **46:** 662–664, April 1941.

3. EVANS, T. C., GOODRICH, J. P., AND SLAUGHTER, J. C.: Low Temperature and Radiosensitivity of Skin of New-Born Rats. III. Resistance at Different Temperatures. Proc. Soc. Exper. Biol. & Med. **47:** 434–437, 1941.

4. FAILLA, G.: A Theory of Biological Action of Ionizing Radiations, in Cancer Problem Symposium, New York, Science Press, 1937, pp. 202–214.

5. FAILLA, G.: Some Aspects of the Biological Action of Ionizing Radiations. Am. J. Roentgenol. **44:** 649–664, November 1940.

6. FAILLA, G., AND SUGIURA, K.: Experimental Results Supporting the "Fluid Flow" Theory of the Biological Action of Ionizing Radiations. Science **89:** 438, 1939.

7. SUGIURA, K.: Studies on Radiosensitivity of Mouse Sarcoma 180 Irradiated in Vivo and in Vitro. Radiology **29:** 352–361, September 1937.

8. SUGIURA, K.: Effect of Injections of Distilled Water on the Growth of Irradiated Mouse Sarcoma 180. Am. J. Roentgenol. **43:** 533–538, April 1940.

X-Ray Protection in Diagnostic Radiology[1]

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MOST STUDIES of x-ray protection have been devoted to the high-voltage or supervoltage field, and a number of dependable reports are available on this subject. As a result there is today little difficulty in constructing and operating high-voltage therapy installations to meet even the most rigid requirements.

This was demonstrated in a previous paper (1), where it was shown that the stray radiation was less than 1 per cent of the then accepted tolerance dose, 0.2 r per day, in those roentgen therapy departments which were provided with protection in accordance with the international recommendations (2). This has been further verified over a period of years by means of dental films carried by the staff of the roentgen therapy units of the Division of Cancer, Department of Hospitals, City of New York. In diagnostic roentgenology, on the other hand, it is more difficult to maintain such a high factor of safety, and in some instances the tolerance dose is greatly exceeded.

There are several factors which make the question of protection in diagnostic radiology of particular importance. First of all, x-ray equipment is used most extensively for diagnostic purposes, and in many cases by physicians not specializing in radiology, to whom the main interest is the diagnostic result with too little consideration of safety. Often the use of so-called ray-proof apparatus results in a false sense of security. Furthermore, during fluoroscopy and certain radiographic examinations the staff is frequently exposed to stray radiation. Finally, the greatly increased diagnostic use of x-rays makes the cumulative dose received by the patient of possible significance from a genetic point of view. This phase of protection has been duly emphasized in various recent papers (3, 4). While this question will not be settled, at least quantitatively, for years to come, all reasonable steps should be taken to avoid unnecessary irradiation of the gonads of patients who have not passed the reproductive age. But neither should the other and more immediate effects be disregarded, as skin damage and detrimental systemic changes.

In order to reduce these hazards, it is necessary to have a fundamental knowledge of all the physical factors affecting the protection problem, including the doses received by the patient and staff during various roentgenologic procedures. The purpose of this paper is to present information for some of the more common operating conditions, from which data for other and special technics may readily be calculated.

The measuring instruments used in this work, shown in Figure 1, were similar to those described in our earlier study of stray radiation in the high-voltage field (1). The ionization chambers had a volume from 600 c.c. to less than 1.0 c.c., giving a sensitivity range from 0.001 to 35.0 r. Where still greater sensitivity and directional effect were required, a Geiger-Müller counter was used. This counter had a response of about one net count per microroentgen. One microroentgen is equal to 0.000001 r.

TUBE ENCLOSURES

Roentgen protective materials may be applied most economically close to the x-ray tube, as the amount required, for the same thickness, varies approximately as the square of the target distance. There is, therefore, a definite saving in using so-called ray-proof tubes, which practically limit the beam to the fractional part ac-

[1] From the Physics Laboratory, Department of Hospitals, City of New York. Presented before the New York Roentgen Society, N. Y. Academy of Medicine, April 21, 1941. Accepted for publication in October 1941.

tually needed for radiologic purposes. With this type of tube it is, of course, still necessary to protect against the primary rays passing through the aperture and the secondary radiation from any object which the primary beam may strike. The effectiveness of the tube protection was determined ionometrically by operating the tube with the aperture closed with 3 mm. lead. The stray radiation was measured around the tube at one meter target distance with the large ionization chamber, and a hand fluoroscope was used to locate any intermediate points of less protection. The tube was operated near its continuous milliamperage rating, that is 4 ma., as the cumulative dose of any series of short exposures of high milliamperage will never exceed that obtained by continuous operation. By multiplying the measured r per hour by the daily working hours, we obtain the maximum possible stray radiation per day, irrespective of how the tube is used, as long as it is not overloaded.

In the case of low-voltage tubes it is not possible to express the stray radiation in terms of the useful beam, as the dosage rate will vary several hundred per cent depending upon the inherent filtration of the tube. The results are expressed, therefore, in roentgens per hour and in equivalent millimeters of lead. The lead equivalent makes it possible to compare the protection of two tubes operating at different voltages.

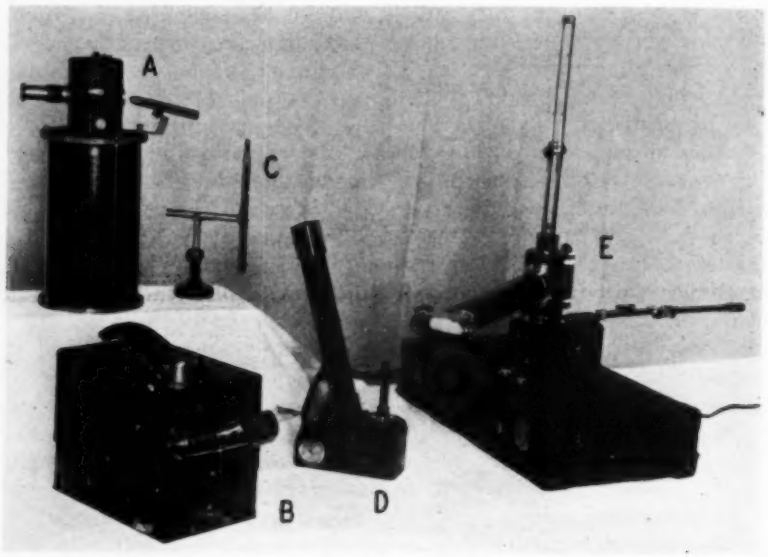

Fig. 1. Ionization instruments. A. 600 c.c. ionization chamber with electrometer. B. Geiger-Müller counter. C. Condenser chamber with stand used for vertical fluoroscopes. D. Condenser r-meter with pocket ionization chamber. E. Modified Wulf type r-meter.

The tabulated results of the measurements are shown in Figure 2, where the schematic diagram shows the test positions. Measurements were made also at other positions, but the results do not differ materially from those shown.

It will be observed that the protection, in general, is high, although it varies greatly with different types of tubes. As might be expected, the self-contained type with tube and transformer in the same tank had the least protection, as the whole tank has to be lead-lined. The location of maximum stray radiation was found to be at "D," that is, at a right angle to the tube axis and central beam. The fluoroscopic examination of the tube head

showed that this was due to lack of sufficient protection at the aperture, causing scattering from the oil, bakelite, and aluminum housing. By adding lead around the port it was possible to reduce the stray radiation to about 1/20 of its original value, thereby doubling the lead equivalent.

In evaluating the significance of the tube protection, it should be borne in mind that the direct stray radiation—that is, that originating from the tube—is only a small part of the total stray radiation received under actual operating conditions. Measurements show that the scattered radiation from the patient is many times as high as the direct stray radiation from the average ray-proof tube. This is shown in Table V.

The great variation in the protective qualities of various tubes shows the need of some standard requirement. While the recommendations of the Bureau of Standards (5) give the minimum amount of protection, expressed in lead equivalent for each voltage, they do not take into account the milliamperage rating of the tubes. The Department of Hospitals (City of New York) specifies that the direct stray radiation must not exceed 1 r per hour at 1 meter target distance, at the continuous milliamperage rating of the tube. We are considering reducing this value somewhat, as this study has indicated that greater protection may now readily be obtained. On the other hand, there is no point in adding so much lead that the tube is unnecessarily heavy and difficult to counterbalance.

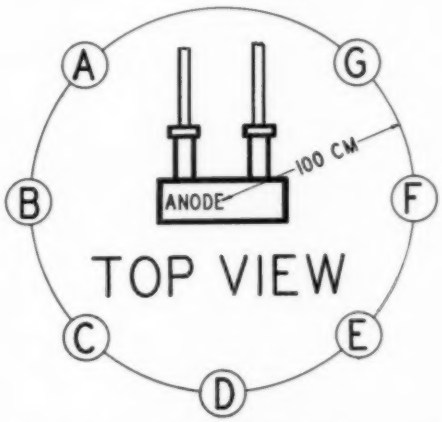

Fig. 2. The stray radiation and lead equivalent of various types of diagnostic tube enclosures at the different test positions were as follows:

Type		Kv. p.	Position A r/hr.	Position A Pb mm.	Position B r/hr.	Position B Pb mm.	Position C r/hr.	Position C Pb mm.	Position D r/hr.	Position D Pb mm.	Position E r/hr.	Position E Pb mm.	Position F r/hr.	Position F Pb mm.	Position G r/hr.	Position G Pb mm.	Remarks
Self cont.	R	80	...	..	0.014	1.57	...	..	0.104	0.98	...	..	0.036	1.28	...	..	.....
Oil ins.	E	80	...	..	0.003	2.18	...	..	0.003	2.18	...	..	0.003	2.18	...	..	.....
Oil ins.	C	80	...	..	0.005	1.95	...	..	0.005	1.95	...	..	0.008	1.77	...	..	.....
Air ins.	S	80	...	..	0.007	1.83	...	..	0.009	1.73	...	..	0.006	1.88	...	..	.....
Oil water	T	100	0.217	1.40	0.022	2.33	0.211	1.41	0.515	1.08	0.281	1.30	0.017	2.44	0.270	1.23	.....
Oil water	T	100	...	..	...	..	0.022	2.33	0.024	2.28	0.020	2.37	0.017	2.44	...	..	Added protection
Oil ins.	T	100	...	..	0.100	1.70	0.138	1.58	0.144	1.56	0.132	1.59	0.074	1.82	...	..	.....
Oil ins.	T	100	0.085	1.77	0.078	1.80	0.049	1.99	0.067	1.86	0.046	2.02	0.039	2.08	0.048	2.00	Added protection
Air ins.	T	100	0.111	1.66	0.094	1.72	0.049	1.99	0.059	1.91	0.048	2.00	0.040	1.98	0.071	1.83	.....

While discussing x-ray tubes, it may be well to consider another factor in their construction affecting safety, namely inherent filtration. The present use of oil and bakelite in addition to the pyrex glass window has increased the inherent filtration of the tube to a varying degree for each type, with resulting difference in r output. This makes it difficult to determine what auxiliary filter should be used in each case. Here, also, is a need for greater uniformity, and it is desirable that tube manufacturers agree on a certain equivalent filtration, say 0.5 mm. Al, for all diagnostic tubes.

FLUOROSCOPY

Of the various diagnostic roentgen applications, fluoroscopy probably presents the greatest radiation hazards to both patient and staff. The dose received by the patient for a given illumination of the fluoroscopic screen depends upon a number of conditions:

(1) *Target Panel Distance:* The greater this distance, the smaller is the dose to the skin of the patient. For instance, increasing the target panel distance from 8 to 12 inches reduces the skin dose about 33 per cent with the same r per minute at the screen.[2] Similarly there is a 10 per cent further decrease in the skin dose by changing from 12 to 14 inches.

(2) *Filtration* (including inherent, added, and that of the panel): The higher the filtration, the smaller is the skin dose. Increasing the added filter from 0.5 to 1.0 mm. Al cuts the skin dose in about one-half without reducing the diagnostic value of the image.[3]

(3) *Size of Field:* The smaller the field the less is the back-scatter and the smaller is the exposed skin area.

(4) *Tube Voltage:* The higher the voltage, the smaller is the skin dose for the same illumination.

(5) *Sensitivity of Fluorescent Screen:* The dose to the deeper tissue, as the ovaries, in relation to the illumination of the screen, is affected in a similar manner as that to the skin, although to a less extent. It appears evident, therefore, that there is no justification for the use of target panel distances shorter than 12 inches (30 cm.) or a total filtration of less than 1.0 to 1.5 mm. Al.

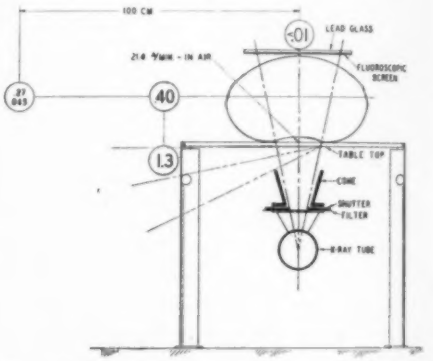

Fig. 3. Stray radiation measurements of horizontal fluoroscope, indicated in r/hour.

During the past years we have measured the r output of large numbers of fluoroscopes, using the settings at which they are normally operated, and have found a very wide variation. This is illustrated in Table I. Attention is called particularly to test B-116, where the r/min. at the panel was 127, that is, an erythema dose would be reached in about three minutes. Such a unit could be classified as a lethal

[2] This may be calculated by applying the inverse square law. If the patient, for instance, is 8 inches thick, the target screen distance is 16 inches in the first case, and 20 inches in the second. As the absorption of the radiation is the same in both cases, the relative doses depend on the distances only. In the first case the dose at the panel is $16^2/8^2 = 4$ and in the second case $20^2/12^2 = 2.78$ times the dose at the screen (neglecting absorption). In other words, the skin dose to the patient has been reduced as the ratio of 4 to 2.78.

[3] This may readily be verified by covering half of the aperture with 0.5 mm. Al. Without the patient in place there is a definite reduction in intensity on half of the screen, while with the patient in place it is impossible to see any difference. This, of course, is due to the fact that the aluminum absorbs mainly the soft rays which otherwise would have been absorbed by the patient. Tests B-116 and B-129, Table I, illustrate this point.

TABLE I: DOSAGE RATES FOR DIFFERENT VERTICAL FLUOROSCOPES

Test	No.	Type of Generator	Make of Fluoroscope	Kv.p.†	Ma.	Filter mm. Al	Target Panel Distance, cm.	r/min. At Panel	r/min. At 30 cm.	Remarks
AT-104	10	Self rect.	D	70	5	1	34.5	13.4	17.7	Minimum for group
BH-217	..	Self rect.	D	85	5	1	35.1	21.7	29.8	Maximum for group
B-113	9	4 Valve	C	66	5	1	33.3	13.2	16.2	Minimum for group
B-108	..	Mech. rect.	C	95	5	1	33.1	19.9	23.0	.....
B-127	..	Self rect.	C	..	5	1/2	22.9	75.9	44.4	Maximum for group
AT-101	2	4 Valve	I	80	5	1	27.6	8.9	7.5	.....
BH-214	..	4 Valve	I	85	5	1	28.2	18.0	16.0	.....
B-114	3	Self rect.	F	..	5	1	33.0	6.8	8.4	Minimum for group
BOP-123	..	Self rect.	F	..	5	1	33.0	21.1	25.6	Maximum for group
B-116	1	Self rect.	H*	..	5	1/2	17.8	*127.6*	45.0	.....
B-129	1	Self rect.	H*	..	5	1	30.5	23.0	23.8	Same as above after increased filtration and distance
B-115	1	Self rect.	A*	..	5	1	31.8	37.9	42.7	.....
3503	1	.....	E	..	5	1/4	35.6	11.6	16.4	.....

* No longer manufactured. † Manufacturer's calibration.

TABLE II: DOSAGE RATES FOR HORIZONTAL AND TILT TYPE FLUOROSCOPES

Test	No.	Type of Generator	Make of Fluoroscope	Kv.p.†	Ma.	Filter mm. Al	Target Panel Distance, cm.	r/min. At Panel	r/min. At 30 cm.
			Horizontal Fluoroscopes						
B-112	2	4 Valve	C	67	5	1	31.1	33.8	36.5
B-128	..	Self rect., shock-proof	C	..	5	1/2	33.0	32.3	39.1
AT-101	1	4 Valve	I	80	5	1	29.2	17.0	16.1
B-116	1	Self rect.	H*	..	5	1/2	43.8	23.8	50.9
3458	1	4 Valve	E	80	5	1/2	36.0	21.6	31.0
			Tilt Type Fluoroscopes						
B-109	3	Self rect.	C	..	5	1/2	27.6	31.5	26.4
B-111	..	Mech. rect.	C	95	5	1	37.5	22.7	35.5
AT-102	2	4 Valve	I	80	5	1	35.7	9.6	13.6
BH-214	..	.....	I	85	5	1	29.0	17.8	16.7
B-118	1	Self rect.	H*	..	5	1	29.9	55.2	54.8
BH-215	1	Valve	E	85	5	1	40.0	11.8	21.1

* No longer manufactured. † Manufacturer's calibration.

diagnostic weapon and yet there are many of these still in use. This particular one was changed to reduce the output, and the results are shown in test B-129.

Similar measurements were made on horizontal and tilt type fluoroscopes, as shown in Table II. A greater uniformity will be noticed here, as the variation in the distance is less.

A study was also made of the stray radiation received by the fluoroscopist. It was found that on the enclosed fluoroscopes, the direct stray radiation measured with the shutters closed, or back of lead glass, was less than 1/1000 r per hour and, therefore, practically negligible. On the other hand, the scattered radiation is by no means insignificant, particularly in the case of horizontal and tilt type fluoroscopes. This is illustrated in Figure 3. On the horizontal fluoroscopes there is usually a space between the end of the trochoscope cone and the table top to permit the movement of the Bucky diaphragm. As a result, there is considerable scattered radiation from the under surface and, contrary to general opinion, this scattering is of much greater intensity than scattering by the patient. The use of lead rubber sheets hanging from the screen between the operator and patient is therefore insufficient unless these extend below

Fig. 4. Scattering at horizontal fluoroscope (film test). The scattering from the heavy patient (left) is much less due to the increased absorption caused by the greater thickness of tissue outside the field. The greatest scattering is from the under side of table top as shown on the right.

the table top. This is demonstrated more clearly in Figure 4, which shows exposures made on films placed vertically next to the table at the position of the fluoroscopist.

Much better protection is afforded on the vertical fluoroscope, as the cone end here comes within a quarter of an inch of the panel, practically eliminating this source of scattering. A similar degree of protection could be obtained on the horizontal fluoroscope by providing its cone with a telescopic extension. Even with this arrangement it is essential that the fluoroscopist use lead rubber gloves and apron or a lead protective chair, although the employment of small fields will reduce materially the scattered radiation (6). The lead rubber should have a lead equivalent of not less than 0.5 mm., and the gloves should have protection between the fingers, too. One of the most common causes of excessive fluoroscopic stray radiation is the use of fields extending beyond the lead glass. This is often due to the sagging of the fluoroscopic screen on poorly constructed vertical fluoroscopes.

RADIOGRAPHY

In radiography the dose received by the patient in relation to the exposure of the film depends upon somewhat similar factors as in fluoroscopy, and in addition on the Bucky diaphragm ratio. In order to obtain an estimate of the dose, we measured the roentgens per 100 milliampere-seconds exposure on different types of equipment. An average value of approximately 5 r was obtained at 80 kv. with 0.5 mm. Al added filtration at a distance of about 20 inches. This is shown in Table III. It will be noted that the maximum variation is relatively small: plus or minus 15 per cent. Using this figure of 5 r and the results of depth dose measurements made for the same conditions, Table IV was prepared to indicate the dose at different levels in the body. The indicated approximate target film distance assumes that the patient is 10 inches thick and the film 2 inches below the table top.

The dose received by the operator during radiography is practically nil at the controls, if located in the usual booths lined with 1.5 mm. lead, 7 feet high, and if ray-proof tubes are used. This assumes the operator actually stays in the booth during the exposure. It is, therefore, good practice to have the patient and aerial meters readily visible through the lead glass window and the exposure switch so located that the operator cannot energize the tube except when fully protected. Just how wide the booth or floor screen should be depends on the lay-out of the room. In general, the rays should be scattered at least twice before reaching the operator. If this rule is carried out, the dose to the operator will be of the order 10 microroentgens per 100 ma.-seconds as determined by the Geiger-Müller counter. People in adjoining rooms should also be protected with the equivalent of not less than 1.5 mm. of lead at least 7 feet high.

Unfortunately, it is not always possible

TABLE III: COMPARISON OF R-OUTPUT OF DIAGNOSTIC X-RAY EQUIPMENT

Generator	Tube	Kv.p.	Ma.	mm. Al	At 50-cm. Distance (20 in.—) r/min.	r/sec.	r/100 ma.-sec.
4 Valve	Rotating	50	120	0	218	3.64	3.04
				1/2	123	2.05	1.71
		80	120	0	470	7.85	6.55
				1/2	324	5.40	4.51*
3 Phase	Oil insulated	80	100	0	536	8.94	8.94
				1/2	334	5.56	5.56*
				1	248	4.14	4.14
1 Valve	Oil insulated	80	10	1/2	30.1	0.505	5.05*
4 Valve	Air insulated	80	10	1/2	25.0	0.416	4.16*
		80	...	1/2	...	...	4.82 Aver.

* Values used to compute averages.

TABLE IV: AVERAGE DOSE IN ROENTGENS FOR EACH 100 MILLIAMPERE-SECOND EXPOSURE AT 80 KV.P. AND 0.5 MM. AL ADDED FILTRATION

Target skin distance	30 cm.	40 cm.	50 cm.	60 cm.	70 cm.	150 cm.
Approximate target film distance	12 in. — (24 in.)	16 in. — (28 in.)	20 in. — (32 in.)	24 in. — (36 in.)	28 in. — (40 in.)	5 ft. — (6 ft.)
r in air	14	7.8	5.0	3.5	2.6	0.56
r at skin	17	9.7	6.2	4.3	3.1	0.68
r at 3-cm. depth	8.2	4.8	3.2	2.2	1.7	0.39
r at 5-cm. depth	5.1	3.1	2.1	1.5	1.1	0.26
r at 7-cm. depth	3.1	1.9	1.3	0.90	0.72	0.17
r at 10-cm. depth	1.6	1.1	0.71	0.54	0.40	0.10

TABLE V: COMPARISON OF DIRECT AND SCATTERED STRAY RADIATION

(80 kv.p., 4 ma., 0.5 mm. Al, 50-cm. (20 inches—) target skin distance)

Field Diameter, cm.	Useful Beam Measured in Air r per Min.	r per Hour	Type of Stray Radiation	Stray Radiation at 1 Meter† r per Hour	% of Useful Beam	r per 100 ma.-sec.	Ratio
0*	....	...	Direct	0.009	0.001	< 0.0001	1.0
8	16.3	978	Direct and scattered	0.031	0.003	0.0002	3.5
25	....	...	Direct and scattered	0.284	0.029	0.0020	32.0
35	....	...	Direct and scattered	0.717	0.073	0.0050	80.0

* Aperture closed with 3 mm. lead.
† Stray radiation measured at a position corresponding to "D" in Figure 2, that is, at right angle to tube axis and central beam.

for the staff to remain behind protective barriers during the exposure. Patients, particularly babies, often have to be supported or held while the x-ray tube is energized, dental units are used without protective screens, and the cystoscopist is exposed to secondary radiation. In order to determine the amount of scattering from the patient, measurements were made at a distance of 1 meter from the center and at a right angle to the central beam. The results, shown in Table V, indicate the great effect the size of field has on the amount of scattering. The amount of stray radiation makes it advisable for members of the radiologic staff never to expose themselves to scattered radiation if the work can be entrusted to nurses and orderlies who are not normally exposed to the rays.

MOBILE UNITS

Of the various types of radiologic equipment, the mobile unit probably has been responsible for more radiation damage than any other piece of apparatus. *These accidents have in most cases occurred while the mobile unit was used for fluoroscopy by surgeons, who apparently did not realize the high output obtained at short distances.* Meas-

urements show that at the shortest possible distance, about 8 cm., the r per minute is as high as 1000 without filter at 85 kv. and 5 ma. To avoid these excessive doses it is recommended that all mobile units be provided with fixed cones or a frame arrangement preventing the target skin distances from being less than 30 cm. (12 inches). In addition, the aperture should be provided with a fixed filter of not less than 1.0 mm. Al.

DENTAL RADIOGRAPHY

There has been an unfortunate tendency to disregard entirely the question of protection in the field of dental radiography, although the stray radiation is far from negligible. The operator receives approximately 0.1 r for each eight mouth examinations consisting of ten three-second exposures. This assumes that the x-ray beam is directed away from the operator, which is not always the case.

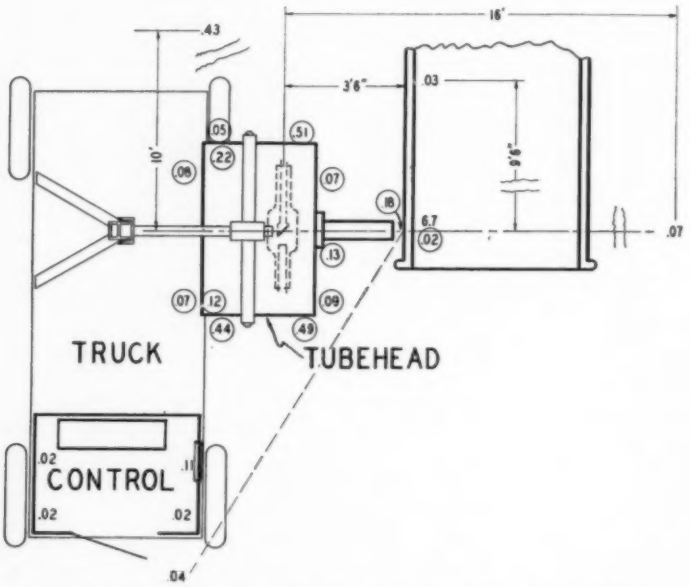

Fig. 5. Stray radiation survey of 400 kv. industrial unit. Figures indicate r per eight-hour day. Circled figures show measurements with shutter closed.

A considerable amount of bedside radiography is done in the larger hospitals, and it is therefore important to consider the protection of the operator of the mobile unit. Tests show that the average stray radiation at the technician's position, 1.5 meter from the tube, is about 0.004 r per 100 ma.-second exposure. It is advisable, therefore, to rotate the technicians doing mobile work, or have them wear lead rubber aprons.

In cystoscopy, also, the question of stray radiation deserves attention. At the cystoscopist's position the r per 100 ma.-second exposure was found to be about 0.02.

INDUSTRIAL RADIOGRAPHY

Although industrial radiography, strictly speaking, is not a part of radiology, a few important points relating to the hazards in this field should be brought out. In radiographing small industrial objects, a high degree of safety may be obtained by using similar safeguards as in medical radiography, that is, by enclosing both the object and the x-ray tube in properly shielded rooms. That this is not always carried out in an effective manner has been due to lack of knowledge rather than neglect. For radiographing large objects, such as high-pressure vessels, the use of separate

TABLE VI: RESULTS OF MONTHLY STRAY RADIATION FILM MEASUREMENTS IN DIAGNOSTIC X-RAY DEPARTMENT*

Cassette	Function	Density O	0.5 mm. Al	0.5 mm. Cu	0.5 mm. Pb	Dose
76	Director	0.16	0.16	0.16	0.16	None
82	Residents	0.36	0.34	0.18	0.18	0.08 r
83	Residents	0.48	0.42	0.12	0.16	0.12 r
84	Nurse	0.26	0.23	0.15	0.15	0.04 r
85	Nurse	0.66	0.55	0.16	0.14	0.20 r
86	Nurse	0.36				0.08 r
87	Nurse	0.24	0.24	0.22	0.20	0.03 r
77	Chief technician	0.18	0.16	0.16	0.16	None
78	Technician	0.15	0.15	0.15	0.15	None
79	Technician	0.18	0.18	0.17	0.17	None
88	Technician	0.17	0.17	0.16	0.16	None
89	Technician	0.14	0.14	0.14	0.14	None
90	Technician	0.13	0.13	0.10	0.10	None
91	Technician	0.26	0.26	0.24	0.24	0.04 r
93	Technician	0.23	0.23	0.15	0.15	0.03 r
95	Technician	0.14	0.14	0.14	0.14	None
96	Technician	0.16	0.16	0.16	0.16	None
97	Technician	0.13	0.13	0.13	0.13	None
98	Technician	0.15	0.15	0.15	0.15	None
99	Technician	0.15	0.15	0.15	0.15	None
100	Technician	0.42	0.40	0.26	0.15	0.10 r
14	Test film 0.5 r at 80 kv.p.	1.50	1.32	0.28	0.20	...
Blank (unexposed film)		0.14				

* The films were carried in special cassettes, each provided with a filtration ladder of 0.5 mm Al, Cu, and Pb, in addition to an unfiltered area. The average density for each area is shown in corresponding columns above.

shielded rooms is not practical, and in most cases is impossible, as this would require ray-proofing of walls perhaps 50 to 75 feet long. The usual practice is to provide complete protection for the operator by using a lead-lined control booth, then to direct the rays in such a way that the stray radiation received by other workers is considerably below the safety limit. Figure 5 illustrates the protection obtained with such an arrangement. The film is placed inside the pipe and the worker then moves out of the field during exposure. It is quite obvious that unless care is taken in the operation, the personnel may receive considerable exposure. Should the x-ray machine be operated with the shutter open, for any reason, and without any object in front of it, the radiation received as far away as 100 feet may greatly exceed the tolerance dose.

This phase of protection is of particular importance at the present time, as a large number of new industrial units are being put into operation. The likelihood of insufficient protection is quite great, as many of the new users may not be fully aware of the harmful effects of the rays. Some plants are using radium in place of x-rays and there the problem is even more serious. As a tube of 100 mg. or more of radium is usually employed, it is obvious that careless handling may soon cause permanent damage to the personnel.

DISCUSSION

The results of our measurements indicate clearly the need of a periodic check on the stray radiation received by the radiologic personnel. This may be accomplished most accurately by means of pocket ionization chambers similar to the one (D) shown in Figure 1. An approximate yet satisfactory check may be obtained by means of dental films carried for a period of a month. While film stray radiation determinations are subject to numerous errors due to differences in film sensitivity, dark room procedure, ray quality, etc., they are sufficiently dependable to indicate whether or not the more accurate ionization measurements are required. The test films should be compared, by means of a densitometer, with control films exposed to known fractions of a roentgen, using similar ray quality.

The film tests have the advantage, also

that they may give an indication of the ray quality if parts of the film are covered with different filter materials. A knowledge of the ray quality serves to indicate the origin of the stray radiation, whether it is due to radium, high-voltage or low-voltage x-rays. The results of such periodic film tests in a large hospital are shown in Table VI. As might be expected, the nurses holding the patients and the doctors doing fluoroscopy were those receiving the largest amounts. In no case, however, did the dose exceed 0.2 r per month, indicating a large factor of safety at this particular hospital.

In conclusion, it should be emphasized that of the three factors affecting radiation protection—equipment, structural shielding, and operating procedures—the last is by far the most important in diagnostic radiology. Unless the roentgenologist gives his continued attention to this phase and has his staff do the same, it is not possible to secure satisfactory x-ray protection.

NOTE: The writer wishes to acknowledge the assistance rendered by Mr. Gordon H. Cameron of this laboratory with the experimental work.

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REFERENCES

1. BRAESTRUP, C. B.: A Stray Radiation Survey of Twenty High-Voltage Roentgen Installations. Radiology **31:** 206–213, August 1938.

2. International Recommendations for X-Ray and Radium Protection Revised by the International X-Ray and Radium Protection Commission at Fifth International Congress of Radiology, September 1937.

3. WESTING, S. W.: Importance of a New X-Ray Effect for Our Daily Diagnostic and Therapeutic X-Ray Work. New York State J. Med. **40:** 1139–1144, Aug. 1, 1940.

4. HENSHAW, P. S.: Biologic Significance of the Tolerance Dose in X-Ray and Radium Protection. J. Nat. Cancer Inst. **1:** 789–805, June 1941.

5. X-Ray Protection, National Bureau of Standards Handbook HB 20, published 1936.

6. LEDDY, E. T., CILLEY, E. I. L., AND KIRKLIN, B. R.: Dangers of Roentgenoscopy and Methods of Protection against Them. Am. J. Roentgenol. **32:** 360–368, September 1934.

General References

COWIE, DEAN B., AND SCHEELE, L. A.: A Survey of Radiation Protection in Hospitals. J. Nat. Cancer Inst. **1:** 767–787, June 1941.

RENDICH, R. A., AND BRAESTRUP, C. B.: X-Ray Department. Hospital Yearbook, 19th Edition, 1941.

TAYLOR, L. S.: X-Ray Protection. J. A. M. A. **116:** 136–140, Jan. 11, 1941.

The Specialist as a Naval Medical Officer[1]

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IN THESE DAYS of alarms and excursions, wars and rumors of wars, many in civil life must be giving thought to the possibility of serving in the Army or Navy in their professional capacity. Those who contemplate such a move must be wondering just what military or naval service would mean to them. I shall try to describe some of the work of the naval medical officer under various conditions at sea or ashore.

Many doctors have entered the Naval Reserve and are now serving on active duty. It has been my privilege to serve with a number of them and I am glad to pay tribute to the willing, cheerful manner in which they have so efficiently aided the rapid expansion of the Naval Medical Department. They have in some cases sustained a violent dislocation from their accustomed daily life into a strange environment. They have almost without exception accepted the situation gracefully and adapted themselves quickly to the new conditions.

When the medical man wishes to enter the Naval Reserve, he makes application to the Bureau of Medicine and Surgery at the Navy Department in Washington. If he is professionally and physically qualified he receives a commission in the Reserve. A physician with recognized standing in a specialty such as medicine, surgery, radiology, otolaryngology, etc., is given the designation of MC-V(S) USNR, meaning Medical Corps Volunteer Specialist, U. S. Naval Reserve. The rank he receives on entering the service depends on his years of experience in his specialty, his standing therein, and his personal abilities. If he is not a qualified specialist his designation is MC-V(G) USNR, meaning Medical Corps Volunteer General, U. S. Naval Reserve. Again his rank is determined by his qualifications, experience, and abilities. Needless to say, most of the officers with the designation MC-V(G) USNR are the younger men who have graduated so recently that they have not become recognized specialists.

There are other classes of reserve medical officers, as the organized reserves, *i.e.*, medical reserve officers who belong to some organized naval reserve unit of the line of the Navy and may be called with that unit to active duty, and the MC-M, USNR, the M indicating that the medical officer has served as doctor aboard ship in the merchant service.

There are, in addition, specialist units which have been organized throughout the country. Usually at some hospital or clinic a reserve medical officer of the rank of Lieutenant Commander or above acts as organizer of such a unit. These units consist of groups of specialists, an internist, surgeon, eye, ear, nose, and throat specialist, radiologist, orthopedic man, laboratory man, and psychiatrist, making up a typical unit. This group, headed by the organizer, who is a specialist and usually the senior man of the group, is assigned a number and becomes known as Specialist Unit No. —, whatever the number may be. The purpose is to furnish a group which may be ordered as a unit to duty at a hospital or such other place as it may be needed. Not all units are clinical. The Navy, for example, has in the San Francisco area a Laboratory Research Unit headed by Dr. A. P. Krueger, Professor of Bacteriology, University of California. This unit is now on active duty, doing excellent work in the field of preventive medicine.

Not all specialists are members of a unit, for any doctor who is a recognized specialist in his field may receive the desig-

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nation of MC-V(S) in the Reserve. Nor is membership in a specialist unit necessarily a guarantee that an individual will not be ordered to duty independent of the other members of his unit. Some units as such have been ordered to active duty. Many members of units have requested active duty and been ordered to stations or ships where their services are needed.

It is obvious that when ordered to active duty, the specialist in the Reserve Corps needs no more training in his specialty. He does, however, require a period of adjustment and adaptation to Navy ways. He may need refresher work in other branches of medicine than his specialty, for in the vicissitudes of war he may find himself as the only medical officer of a ship at sea. Certainly he will need to think in terms of preparation for war and war casualties. This matter of training for war and the care of battle casualties is one of the outstanding differences between civil and naval medicine. The term "naval medical officer" might well be changed to "medical naval officer," and it is training as a naval officer which the newcomer to the Medical Department of the Navy must acquire.

On requesting active duty, the reserve medical officer is usually ordered to a naval hospital for his first duty. There are at present 19 naval hospitals in the United States, with several others building and nearly ready to be placed in commission. In addition there are a number of naval hospitals in outlying possessions of the United States, either as permanent establishments or mobile units. There are two hospital ships now in commission. These are not merely ships for transport of ill and wounded from place to place, but completely equipped floating hospitals prepared to provide definitive treatment and care up to full recovery of the patient. These ships are used with the fleet as auxiliaries and provide hospitalization for those units of the fleet which are not near a shore hospital.

In accordance with an Act of Congress, most of the naval hospitals in the continental United States make provision for the care of women and children who are dependents of naval personnel. The naval medical officer, therefore, is not entirely restricted to care of the male sex.

The organization and internal administration of these hospitals are not greatly different than those of a large metropolitan hospital, except that the entire staff is on a full-time basis. They have no other duties than their hospital service. A senior Captain of the Medical Corps of the Navy is in command of the hospital and is responsible for its administration. An Executive Officer, second in command, directs the administration. Each of the various services, as medicine, surgery, eye, ear, nose, and throat, radiology, and physiotherapy, has its own chief, though in the smaller hospitals several services are grouped under a single chief. The administrative section is made up of warrant officers of the Navy, with the rank and title of pharmacists, who head the departments of records, supplies, commissary, etc. The nursing service is headed by a chief nurse of the regular Navy, who directs both female nurses and hospital corpsmen.

Of the Hospital Corps I shall speak more fully later, as these constitute a very important cog in the machinery for the care of the sick in the Navy.

The naval reserve medical officer, having been ordered to a naval hospital, finds his place in its organization. If he is a specialist he is almost invariably placed on the service of his specialty. In the bustle of mobilization and rapid expansion, however, it is unavoidable that certain services may be over-staffed and others short of men. If there are twenty surgical specialists and only three in internal medicine, some of the surgeons have to be placed on the medical services at least temporarily. The new officer, however, soon finds his niche and adjusts himself to it. What are the new things he needs to learn during this tour of hospital duty? Administrative work, navy records, and handling of enlisted men are the most important.

The administrative work is not difficult to grasp. Certain records of the sick must be kept. Certain data must be recorded and forwarded to a central clearing house—namely, the Bureau of Medicine and Surgery in Washington. Although the records to be kept and submitted may at first seem confusing to the new medical officer, the routine is easily and quickly learned. The administration of a ward and handling of men are more difficult. Some men have a natural flair for it. To others it is only drudgery. The new medical officer serves at first as assistant in a ward, but soon is made a ward medical officer with the problems of administration on his shoulders. He has a nurse, who may at this time be as new in the service as himself, six to eight hospital corpsmen—some new, some experienced—and a group of thirty to fifty patients, to be made well as soon as possible or, if they cannot be made fit for duty, separated from the service by proper legal means, in order that their places in the Navy may be filled by fit men.

All officers of the staff below the rank of commander serve a twenty-four-hour tour of duty as officer of the day, usually about once in ten days, depending on the size of the hospital and the number on the staff. This involves acting as admitting officer, making evening sick calls, inspecting meals, directing ambulance trips, rendering emergency treatment, inspecting the hospital buildings and grounds, and taking the rôle of general factotum. The officer thus becomes acquainted with all wards of the hospital and phases of naval hospital duty.

After several months of such duty, the reserve medical officer is usually well versed in naval duties, as far as hospital service is concerned. The acute surgical and traumatic emergencies which arise during his tours as officer of the day have acquainted him with the proper handling of such cases if he were rusty on it before. In the hospital he has had the surgical staff to stand behind him and take over if necessary. Later, when he may meet such emergencies without assistance, he will be grateful for the experience as officer of the day. He has become familiar with records and reports, which no longer seem an insuperable obstacle, and he has learned naval terms and language.

After several months of hospital duty, the reserve officer may be ordered to sea, to foreign shore duty, or to another station in the United States, as an air station, dispensary, or recruiting service. He may, of course, remain at the hospital, and if he is a member of a specialist unit, he will quite likely stay until that unit, as a group, is ordered to some other station. Specialist units may be ordered to new hospitals being opened or to newly commissioned hospital ships.

At most of the naval hospitals, the staffs at present are predominantly reserve medical officers. The officers of the regular establishment, particularly the younger officers, have been ordered to sea duty to serve on newly built or newly acquired ships. At Mare Island Naval Hospital the reserve medical officers comprise 80 per cent of the staff, and the average tour of service has been about six months. In the past year, the turnover of reserve medical officers has been nearly 100 per cent. Some of these men have gone to sea aboard combatant ships, some have gone to navy yard dispensaries, one to recruiting duty, three to a naval air station, two for instruction in aviation medicine, one to Alaska, and several have been sent to the Asiatic station.

Before speaking of these special types of duty, I should like to speak briefly of the Hospital Corps. These young men who are enlisted in the Navy constitute a valuable branch of the Medical Department. They are picked from the newly enlisted men at the training stations, usually volunteering for the Hospital Corps. They are given a course of training in the fundamentals of caring for the sick and then sent to a hospital for several months, where they do practically all the nursing under the direction of a trained navy nurse. In addition to nursing, the

hospital corpsmen serve as typists, keep records, act as masters at arms, truck drivers, accountants, property men, pharmacists, etc. They all learn first aid, and for many years have been sought by large industrial plants as first-aid men when their enlistments have expired. They are promoted to all the grades as is any enlisted man in the Navy, up to Chief Petty Officer, and they are eligible for promotion to warrant rank.

At all stations, other than at hospitals and hospital ships, they are the only fully trained assistants and nurses the medical officer has, and he must lean heavily on them. During their naval career, they are given opportunity for special training in various branches and many have become specialists in pharmacy, x-ray technicians, dental assistants, accountants, operating room technicians, laboratory technicians, etc. The medical officer on ship board is fortunate if he has among his rated hospital corpsmen some men with special training and long service to relieve him of many of the details of care of property, first-aid training, etc. Incidentally, just as the Medical Corps of the Navy has been expanded by the induction of reserve medical officers, so the Hospital Corps has been expanded by the enlistment of hospital corpsmen in the Reserve with petty officer rating according to their ability and specialty in civil life.

The hospital corpsmen are an important part of the Medical Department. They serve many functions well at naval hospitals, but on ships or at stations other than hospitals the medical officer finds himself especially dependent on them for assistance. They constitute his crew, which he must use and direct to carry out his mission.

As stated above, the reserve medical officer may be ordered to sea duty after a period of indoctrination at a naval hospital. Naturally, an effort is made to order specialists to duties where their particular qualifications can be best used. This may be at sea as well as ashore. Quite likely the first sea duty will be as junior medical officer of a combatant ship. Large ships, such as battleships and aircraft carriers, carry two or more medical officers, while cruisers carry at least two. In the destroyer force there is one medical officer for each destroyer. The auxiliary ships, such as transports, tankers, repair ships, and supply ships, have at least one medical officer each. The larger transports usually have two or three, depending on the size of the crew, number of men carried, etc. Naturally the duties of the medical officer vary in detail with the type of ship. For combatant ships, the battleship may be taken as representative. Cruisers and aircraft carriers vary from the battleships but little in type of medical department equipment and duties of the medical officer. Fortunate indeed is the newly inducted medical officer who is assigned to duty on a battleship, for he quickly learns what naval medicine really is, and the ways of the sea. Roughly, his work comes under three general headings: preventive medicine, care of the sick and injured, preparation for battle.

In the field of preventive medicine, the medical officer is responsible for the health of a small community, the entire personnel of his ship, which may number up to nearly 2,000 men. He must deal with problems of ventilation, inspection of food and food handlers, inspection of galleys, pantries, and storerooms, problems arising in overheated firerooms, industrial hygiene in workshops, including proper lighting and the use of safety devices on machinery. All of these and other problems arise in the field of preventive medicine. In addition, proper vaccination and administration of typhoid vaccine must be carried out for all hands. Recently immunization against yellow fever and administration of tetanus toxoid to all naval personnel have been ordered. If these measures have not been carried out on all men, the ship's medical officer must attend to them. Another duty is the fight against venereal disease, which the medical officer carries on by repeated lectures to all the crew.

For the care of the sick and injured, each

ship is well equipped. The sick bay on a modern battleship consists of about twenty-four bunks. There is an isolation ward of two to four bunks and on some ships a quiet room containing one or two surgical beds where seriously sick patients or postoperative cases may be cared for. There is a small but completely equipped operating room with modern operating lights, operating table, and all instruments necessary to carry out almost any surgical procedure from circumcision to a subtemporal decompression. There is a complete set of sterilizers, including autoclave and hot and cold water sterilizers and sterilizers for instruments.

The pharmacy and laboratory are usually combined in one small room and the medical officer's office and examining room may also serve as a record office. There is a dental office with one or two chairs. A dental officer is a member of the medical department of the ship. A portable x-ray machine is provided, with accessories and developing facilities. There is a short-wave diathermy machine, and the larger ships have heat lamps, infra-red lamps, etc. In fact, the whole set-up is that of a compact small hospital. The sick bay is usually located on the second deck of the ship, that is one deck below the main deck, the one on which you step when you go aboard.

At the sick bay the medical officers make sick call. The ship routine usually requires this to be held at 8:00 A.M., so that those men who wish to see the doctor, but who are not unfit for work, may speedily return to their duties. The number of men reporting to sick bay at this time varies with the season and the presence of epidemic colds, etc. More men, also, will report for sick call when the ship is at sea underway, than when it is in port with a possibility of shore leave for the crew in the afternoon. A great majority of those reporting at sick call have minor ailments or complaints, as a cold, a jammed or bruised finger, a cracked toe, or a sprained wrist. Each case, however, takes time, and the medical officer must ever be alert, for the seemingly minor complaint may prove to be a clue to serious trouble. A sprained wrist may mean a fractured scaphoid and a simple stomach ache which the man fails to mention when asking for a cathartic may be the onset of appendicitis. Incidentally, the medical department of every ship is always on the lookout for this disease, and practically all medical officers forbid their corpsmen to dispense cathartics to anybody complaining of abdominal pain without first referring him to a medical officer.

After completion of sick call for the crew, the medical officers visit the patients in the sick bay, examining and ordering treatment for those who are confined to bed or unable to work. Usually the greater part of the forenoon is occupied in examinations and treatments. Emergency operations may have to be performed and in the maze of machinery which constitutes a modern battleship, there are always minor injuries to be treated. Complete physical examinations are done on all men prior to discharge from the service or reenlistment. Work in the sick bay takes practically all the time of one medical officer. The medical officer who may at a hospital on shore be a specialist in one branch of medicine finds himself at sea confronted with problems in many fields. He must be prepared to do an emergency appendectomy, open an ear drum, reduce a fracture, clean up and suture a lacerated wound, diagnose and treat pneumonia, treat the acute shock of a severe injury or of a coronary thrombosis. In these days of specialization in the practice of medicine, the medical officer at sea comes nearer to being the real general practitioner than any doctor on shore.

In preparation for battle, the medical officer aboard a combatant ship has many problems to meet. The main function of a battleship is to hurl shells, and everybody and everything on it must contribute to this function. The medical officer's duty is to prepare his department to keep the men at the guns as long as possible, afford prompt care for wounded and in-

jured during an engagement, and rapid evacuation of dead and wounded from gun stations during a lull in action or after battle. Plans must be formulated, supplies distributed, and personnel trained constantly to carry out these plans.

On most battleships, the sick bay is located in a place which is favorable for good ventilation and away from noisy machinery and heat of boilers. This means that it is not behind armor, and just before any action the patients and sick bay equipment must be moved to protected areas on lower decks. The possibility that a shell hit may destroy medical supplies makes it imperative that there be two or more stations where medical supplies and personnel are located. The dressing stations are the battle stations of the medical officers and some of the corpsmen. Each dressing station is equipped with the material and personnel to form an operating team which can care for wounded brought to it.

The compartmentation of modern ships to preserve water-tight integrity makes it impossible to move wounded men around the ship during action. Before going into action all water-tight doors and hatches are closed, and it is only in dire necessity, to put out fires or repair vital damage, that they may be opened until the action is over. This means that groups of men, such as gun crews, machinists, firemen, etc., are locked in compartments where they must depend solely on one another for first aid and relief of pain until the action is over. In order to provide this assistance, it is necessary that some medical material previously be placed in each compartment and all members of the crew be trained in the principles of first aid and the use of the material available. This is the responsibility of the medical officer, and the training of the men in first aid is carried on continuously. At one time only leading petty officers at each station were trained, but it was noted theoretically that the men trained might be killed or disabled, leaving the others with no skilled help. So in small groups the entire crew is instructed in the proper application of a tourniquet, proper method of applying a shell wound or first aid dressing and bandaging it in place, how to administer morphine, how to carry a wounded man, etc. This instruction is given while they are at their battle stations. Demonstrations are given and the men are thoroughly indoctrinated by practice on one another. During drills, the medical officer may go to a gun casemate and tag certain men as dead or wounded, the tag stating the nature of the wound. The wounded will then drop out at a given signal and their shipmates present administer the necessary first aid; replacements for the wounded fill in at the gun and the drill goes on.

This may seem rather gruesome but the men appreciate the opportunity to learn and it gives them a sense of security to know that if actually wounded or burned in action, they will not suffer needlessly or die for want of immediate skilled attention. Most of them play the rôle of the wounded or dead with enthusiasm, and were it not a really serious business, it would be amusing to hear the simulated moans of pain and see the physical contortions of a colored mess attendant tagged as "shell wound of left thigh, bleeding freely," for the edification of his messmates. The men usually learn their lessons well and sometimes surprise the instructor with their literal interpretation of his orders. On lecturing to the men, one medical officer made the point that wounded and dead men must be kept clear of the gun, that nothing might interfere with its being worked. A little later, while the ship was having drills at the anchorage in Pearl Harbor, he was greatly surprised to see a gun crew pick up one of its members who had been tagged as dead and calmly heave him overboard. Fortunately, the dead man was a good swimmer and suffered no ill effects. In fact, he enjoyed the ducking, although it was suspected that his messmates seized the opportunity of his simulated demise to subject him to a bit of hazing.

Stretcher parties must be trained in handling the wounded and immediately

after action they will collect all seriously wounded and transport them to a designated dressing station where the operating teams may attend them. The medical officer trains the stretcher bearers and drills them in different methods of carrying wounded men. Operating teams must receive training and reliefs are trained and provided for each man, for any may himself be a casualty. Just as drill at the guns is being constantly carried out, drills by the medical department must go on that each of its personnel may be thoroughly trained and ready to do his part in "keeping the ship shooting."

Duty aboard ship is thus full of interest and a busy assignment. Organizing, training, and preparing for battle stimulate the medical officer's initiative. His shipmates, officers, and crew feel that he is an integral part of the ship's company and not just a doctor along on the trip.

The duties on other ships than combatant types do not differ greatly from those aboard battleships, except that special problems may arise. The medical officer aboard a submarine tender, a salvage ship, or rescue vessel, will have problems in regard to deep sea diving and life aboard submarines to solve. On aircraft carriers and tenders there are problems of aviation medicine.

One of the greatest rewards of sea duty is the comradeship of other men whose daily life is shared. Only by close association for long days at sea, with each mutually dependent on the other, learning and tolerating the foibles and weaknesses of one's messmates, discovering and admiring their strengths, can one come to realize the deep significance of the term "shipmate."

Although the basic duty of a naval medical officer is at sea, there are many other places where his services are required. He may be ordered to duty at a foreign station, perhaps a hospital in Guam, Samoa, Hawaii, the Philippines or the Caribbean area. Such hospital duty does not differ essentially from that at a continental hospital. Tropical diseases may be encountered, and adjustment to the tropical manner of living is required. Recently naval stations have been commissioned in Alaska and medical officers are on duty there. At all of these stations, the recently inducted medical officer finds that the training he received during his first duty at a naval hospital stands him in good stead, for navy ways are the same the world over.

In the various ramifications of navy duty, we must never lose sight of the fact that the entire naval establishment ashore, its navy yards, bases, training stations, supply depots, and foreign stations have but one common object—the maintenance of the fleet in readiness to meet any threat to our national safety at any place. The share of the Naval Medical Department in this objective is well expressed by the motto printed on the *Naval Medical Bulletin:*

> *"To keep as many men, at as many guns, as many days as possible."*

Photoroentgenography in a Tuberculosis Program[1]

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A SHORT TIME after the discovery of the roentgen rays, various attempts were made to photograph the fluoroscopic image direct from the fluoroscopic screen. Most of these failed for one reason or another. In recent years, however, similar attempts have been more or less successful. Several good motion pictures have been made of various parts of the body, particularly those showing involuntary motion, as the chest, heart, stomach, intestines, etc. One of the greatest handicaps to be overcome was exposure time. The results obtained from motion pictures focused attention on other fields, the principal one being so-called miniature radiography for chest survey work. The factors which led us to believe that satisfactory diagnostic results might be obtained on an economical basis include the following important contributions: (1) perfection of x-ray tubes; (2) improvement in fluorescent screens; (3) application of scientific advances made in the optical art; (4) improvements in film emulsions; (5) improvements in transformers; (6) building of condensers.

De Abreu of Rio de Janeiro should be given credit for first applying this method, in 1936, to a large number of persons in a survey. He employed a Contax camera to photograph the fluoroscopic image on a 35-mm. film. Janker and Ulrici of Germany used this technic quite extensively and it is being widely employed in that country today. Lindberg, in America, has adopted De Abreu's technic with some modifications. The Westinghouse X-ray Division has recently announced a new photofluorographic unit, utilizing the 35-mm. film. The U. S. Navy at Norfolk, Virginia, is experimenting with photoroentgenography, using the 35-mm. film with a Leica camera. The patient sits on a hydraulic stool, which is raised up and down for various heights; the instrument is kept stationary.

DEVELOPMENT OF THE 4 × 5 INCH FILM

It is known that the use of the regular x-ray film is the most acceptable means for obtaining diagnostic results of the highest quality, but its cost in group examinations of considerable number is a factor which limits survey work. Potter, working with the General Electric Corporation, after much study and experimentation arrived at the conclusion that the most desirable objective in photography of a fluoroscopic image should be the production of a film small enough to constitute economy in celluloid and yet large enough to be readily interpreted without enlargement, or at least no greater magnification than that provided by a simple reading glass. The 4 × 5 inch film was found to be the optimum size.

The fluorescent screen used is nearly seven times as fast as the usual Patterson screen; it fluoresces with the most intense blue-violet light obtainable today. It is mounted in front of a light-tight box a yard long, which tapers down to receive lenses and cameras behind. At the back of the screen is mounted a lead-glass plate 2 mm. in thickness to protect the films from x-ray fog. The lens is also a specially prepared instrument with a rating of F 1.5. It is a six element 150-mm. lens about 6 inches in diameter and is mounted near the apex in the tunnel with a screen at the opposite end, so that both can be moved up and down for adjustment to the proper level for a patient standing upright. Regular x-ray film was found to be the best type.

This method requires just as much time for placing the patient and making the

[1] Read before the Radiological Section of the Los Angeles County Medical Association, the Trudeau Society of Los Angeles, and the California Tuberculosis Association, at Del Monte, California, April 3–5, 1941. Accepted for publication in August 1941.

exposure as conventional roentgenography but with special film hangers development time is cut materially, as six films can thus be developed instead of only one as formerly. It is to be remembered that the film cost is only a part of an x-ray examination and that consequently the actual saving with the smaller films is only about 20 per cent.

4 × 5 INCH VERSUS 35-MM. FILMS

The Westinghouse X-ray Division states that the 35-mm. film has been for years the accepted standard in Europe and South America. They attribute the tendency toward the use of 35-mm. *roll* film to its many advantages, economy, ease of handling, and rapidity of developing. This tendency is indicated by recent articles in the literature, notably one by Dr. I. Seth Hirsch of New York City. Frederick Tice, describing the miniature x-ray film in a total survey, states that it "represents a new and efficient public health instrument destined probably to general acceptance by all communities with a serious tuberculosis problem." He thinks that "the technical difficulties involved in the production of the 35-mm. film are not insurmountable and the reduction in cost, reaching as low as one cent per film, constitutes a perennial inducement to further research." The actual cost of producing, diagnosing, and recording the results, however, even with 35-mm. film, far exceeds one cent per film.

In Tennessee, the U. S. Public Health Service used the General Electric model No. 36 100-ma. machine, the Westinghouse Dynex A condenser unit, and the Westinghouse Diadex 30-ma. portable machine, utilizing the 35-mm. film for photoroentgen purposes. Satisfactory film density and contrast were not obtained with the Westinghouse condenser unit. The Westinghouse 30-ma. portable proved the most satisfactory, with one-half second exposure. Large and small films were made for comparison in 88 tuberculous contact cases. In this study 11.4 per cent were missed by one interpreter and 5.7 by another. Of the 88 patients, 22 were found to have pulmonary tuberculosis. This amounts to 25 per cent, and seems incredible. We do not know whether this work was conducted properly, that is, under the direct and constant supervision of experienced radiologists and technicians.

In a demonstration by representatives of the Westinghouse X-ray Division in Los Angeles[2] on March 11, 1941, they used a condenser unit which has one-half microfarad capacitance. They plugged in on an ordinary 110 light socket, which happened to be an excellent line. The distance used was 40 inches and the kv.p., depending upon the thickness of the patient, varied from 69 kv. on a 21-cm. chest to 90 kv. on a 28-cm. chest. The exposure time was approximately 1/15 of a second. A Patterson B green-sensitive fluorographic screen was used. The lens had a rating of F 1.5. For viewing the 35-mm. films two types of viewers have been developed. One is made with a small special projector, using a photographic lens to give detail; the other is a desk type. This latter also uses lenses, but the film is viewed by direct transmission and is enlarged.

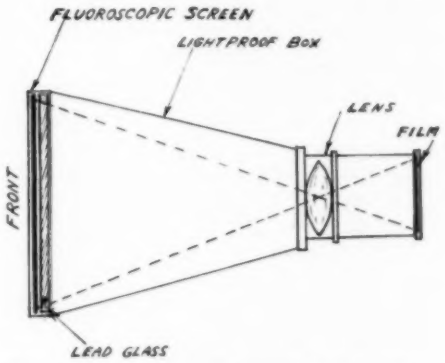

Fig. 1. Cross-section of General Electric photoroentgenographic unit: side elevation.

Eighteen patients were studied, each receiving three exposures at different kv.

[2] I wish to thank the Westinghouse X-ray Division for this demonstration, though I was disappointed that comparative studies were not made. Fortunately in 5 cases large films taken within a month preceding were available; in these cases 4 × 5 inch films were also made, which gave us a basis for comparison.

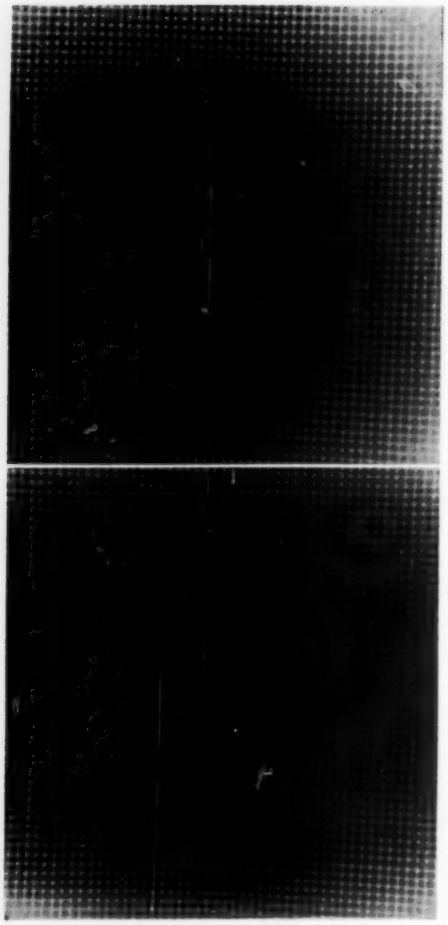

Fig. 2. Wire mesh test, showing little difference between 100 ma. with 1-mm. focal spot (above) and 300 ma. with 2-mm. focal spot (below).

levels. Eighteen of these slides were chosen for our report. All of the films had diagnostic value. As a whole, density was satisfactory and contrast acceptable, but the detail was not very good. I deem it unwise to state, merely from looking at a series of slides or films, that they are good or inferior, as the case may be. Comparison may lead to a very different opinion. Six patients were x-rayed on the 30-ma. portable unit; 2 out of the 6 films were considered of diagnostic value.

It has been said that when De Abreu started his work in South America, it had to be done on 35-mm. film because this was the largest size for which he could obtain an adequately fast lens. It was, therefore, not selected from choice. Another commentator states that those familiar with the average standard of radiographic film quality in Europe and South America know that it is generally well below that accepted by our better qualified radiologists or chest diagnosticians. In speaking of the 35-mm. film, he states that the actual width is 25 mm. instead of 35 mm., and that the size of the area which is covered by the average adult chest is no larger than a two-cent stamp. Potter says that this is too small an image for the most satisfactory work. One technician states that when 24 lines per inch were used with the 35-mm. film in the wire mesh test, the wires could not be identified even by magnification, whereas when the 4 × 5 inch film was used, 60 lines per inch were seen without magnification.

The General Electric Co. has installed a photoroentgen unit in a truck, which is being used in Michigan. They have incorporated the new faster lenses and make exposures utilizing 200 ma. at a 40 inch distance with an exposure time of 1/10 of a second. They state that good films are obtained by this procedure. Another observer states that when the 35-mm. films are read by being projected on a screen, which is necessary because they are too small for direct examination, an objectionable amount of unsharpness appears in the projected image. The procedure of enlargement, in addition to being inconvenient, results in the loss of detail because of an exaggeration of screen graining as well as film graining.

Dr. R. E. Plunkett, General Superintendent of Tuberculosis Hospitals for the State of New York, decided to determine for himself the relative diagnostic merits of the 14 × 17 inch, 4 × 5 inch, and 35-mm. films. The respective units were set up under operating conditions specified by the manufacturer as being satisfactory for operation of each particular generator and photoroentgen unit. For the analysis, it

Fig. 3. Photoroentgen films (chest 19 cm.). Left: 100 ma., 36-inch distance, 76 kv., 1/5-second exposure, developing time 7 minutes with Kodalk. Right: 300 ma., 36-inch distance, 74.2 kv., 3/20-second exposure, developing time $3^1/_2$ minutes with Kodalk.

was decided that 1,000 hospital patients should be radiographed, an independent diagnosis of each film made, and the results correlated to determine the accuracy with which each could be used. The technician at the institution made the 14 × 17 inch films and the manufacturers' representatives made the 35 mm. and the 4 × 5 inch.

The following is quoted from a letter from Doctor Plunkett, dated Jan. 30, 1941: "With reference to the Binghamton study of the 1,000 patients, there were 30 minimal cases. In two of these minimal cases, the lesions were not located on the 4 × 5 inch film. One was located behind a rib, but was apparent in the interspace in the 14 × 17 inch film. It required four 14 × 17 inch films, in two of which it was not sufficiently clear for diagnosis. In the other minimal case, the lesion which was missed was in the extreme lateral portion of the lung and was not discovered in the 4 × 5 inch film. Special mention should be made of the 35-mm. films used in this study; only about 250 of the 1,000 35-mm. films were technically suitable for accurate interpretation. This number, 250, has since been corrected to 615. We would much prefer the 4 × 5 inch film."

There are undoubtedly arguments in favor of both the 35-mm. and the 4 × 5 inch film. In the latter there is, of course, less crowding of detail. It is not, however, in the province of this paper to take sides in this controversy, but rather to advocate photofluorography, because it meets a vital need in economical survey work.

ECONOMY OF SMALL FILMS

By the use of photofluorography we have increased the output in the X-ray Department at East Los Angeles Health Center approximately 50 per cent. Material costs have been reduced proportionately. At the end of this fiscal year, we will have paid for our photoroentgen unit out of savings on films in the Department. Storage space has been reduced at least 65 per cent. It should be emphasized, however, that film cost is only about 20 per cent of an x-ray examination and that, unless large numbers are surveyed, no substantial saving can be made. We have found that the most efficient and economical crew is two x-ray technicians and one clerk. We examine between 75 and 110 chest patients daily, including complete development and clerical work. This number could be materially

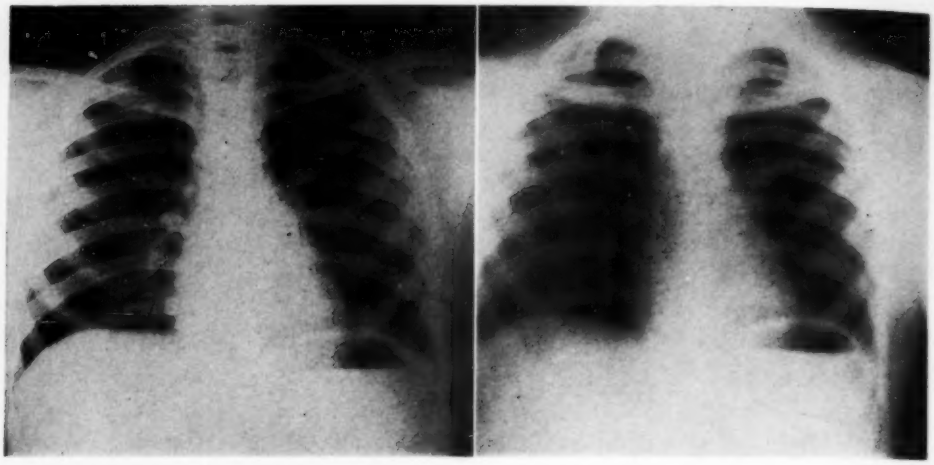

Fig. 4. Chest films. Left: Conventional 14 × 17 inch film, 300 ma., rotating anode tube, 6-foot distance, 1/20-second exposure. Right: 4 × 5 inch photoroentgen film of same patient, 300 ma., 48-inch distance, 1/5-second exposure.

increased if only chest survey work were done. In most reports concerning roentgen studies of large numbers of patients in a day, little is said regarding the time required for processing, interpretation, and clerical work. The actual taking of the film is the smallest part of an x-ray study.

EFFICIENCY OF THE 4 × 5 INCH FILM

Potter, Douglas, and Birkelo found the 4 × 5 inch film "quite accurate," the percentage of error being only 2.6 among 271 cases checked by the large film. The missed cases were all very small minimal lesions which, while requiring follow-up, were not severe. In nearly every instance the missed lesions were superimposed over rib shadows in the small film but were not obscured in the large film.

Ezra Bridge states that the lungs of 1,000 patients have been examined in the Iola Sanatorium, Rochester, New York, with the conventional size film and the small 4 × 5 inch film. Of the 130 minimal cases found, two or 1.5 per cent were missed on the miniatures.

Douglas and Birkelo in another article on "Miniature X-ray Films of the Chest" state that "while tuberculin testing has its place as a diagnostic aid, there are certain disadvantages to its use as a screening device for case finding, such as the inconvenience of repeated visits necessary, interpreting the reaction and repeating it on negatives if a two-dose method is employed. One visit for an x-ray examination will suffice to procure a permanent record if there is a roentgenogram made at the first visit. In general, it is easier to persuade people to have an x-ray examination than to have a skin test."

PROCEDURE IN LOS ANGELES COUNTY HEALTH DEPARTMENT

The technic of producing the 4 × 5 inch film in the Los Angeles County Health Department involves the following factors: 300 ma., from 60 to 85 kv., depending upon the thickness of the chest, impulse timer, rotating anode tube, tube screen distance of 48 inches, average exposure time for adults 1/5 of a second. We have been told recently that there is an industrial film which is so sensitive that we could cut our time in half, in other words to 1/10 of a second. The new General Electric photoroentgen unit is 20 per cent faster than the one that is now in use in our department. We have obtained good diagnostic films by a 3 or 4 kilovoltage increase with 100-ma. technic at 36-inch distance instead of 48 with 1/5 of a second, utilizing the small

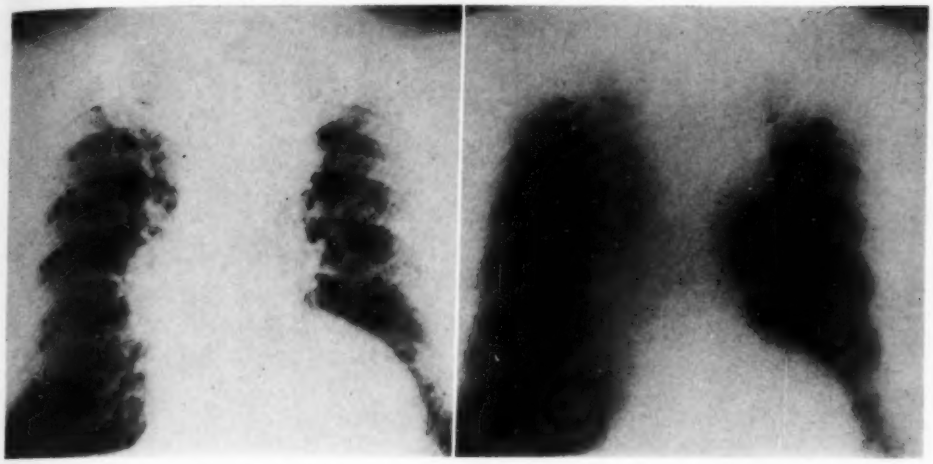

Fig. 5. Chest films of large male patient (28-cm. chest) with hypertensive heart disease. Left: Regular 14 × 17 inch film, 300-ma. current, rotating anode tube. Right: Photoroentgen film. Considering size of patient, the two films are fairly comparable.

(1-mm.) focal spot on the rotating anode tube and developing in Kodalk for seven minutes instead of the usual three and a half or four minutes. We use the small film on all new patients in the clinic, for all survey work for Civil Service applicants, and for comparison where the film has been interpreted previously as negative. *If any suspicious shadows are seen on the film, it is duplicated on the regular 14 × 17 inch x-ray film.* So far we have made 6,000 exposures on 4 × 5 inch films and have not encountered any great difficulties with their use. In one case a small lesion in the base of one lung that was partially obscured by a breast shadow was overlooked. Fortunately, a large film was taken within a short time, demonstrating the lesion. Going back to the small film, we found the lesion to be plainly visible. Two cases presented extraneous shadows. All films were made posterior-anterior only, being part of a survey and *not* a regular roentgen diagnostic procedure. In the latter, posterior-anterior stereoscopic films or posterior-anterior and lateral or oblique films constitute a "proper" examination.

SURVEY FINDINGS

We have used the 4 × 5 inch film to study 2,107 people from the Bureau of Indigent Relief, and report the following findings:

Pulmonary Tuberculosis	
Active minimal pulmonary tuberculosis	10 cases
Moderately advanced pulmonary tuberculosis	3 cases
Far advanced pulmonary tuberculosis	No cases
Cases carried under observation	11 cases
Arrested pulmonary tuberculosis	35 cases
Unclassified tuberculous condition	1 case
Other Pulmonary Conditions	
Pleurisy with effusion	2 cases
Lung abscess	1 case
Bronchiectasis	3 cases
Silicosis	3 cases
Metastatic carcinoma	1 case
Cardiac Conditions	
Aortic aneurysm	1 case
Aortitis	3 cases
Probable cardiac enlargement	12 cases

In this survey no patient whose chest measured over 26 cm., which would require approximately 88 kv.p., was x-rayed on the photoroentgen unit. For such patients—about 5 per cent of the total—the conventional 14 × 17 inch film was used. Retakes on patients measuring under 26 cm. amounted to 1 per cent—no more than would be expected with large films.

The 4 × 5 inch film closely approximates

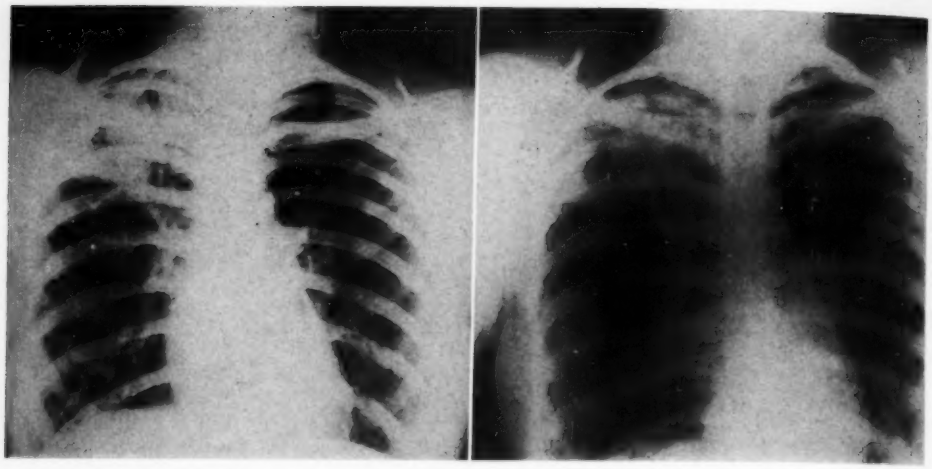

Fig. 6. Chest films, showing pathology with cavitation. Left: 300 ma., 6-foot distance. Right: Photoroentgen film of same patient.

the large film in efficiency, being much better than fluoroscopy, for which Fellows reports a 13 per cent error, as compared with full-size film, and with which no permanent record is made. Films of these dimensions are better than 35-mm. film according to Plunkett's report, and are better than sensitized paper, because they can be transilluminated, and, of course, are much cheaper.

We do not advise small film for private or regular hospital or sanatorium work. We are not using it in our Department for any comparisons on active or apparently arrested cases. Some, however, advise its use in selected cases in the out-patient department of a hospital or sanatorium. It is certainly ideal for examining draftees. One large clinic is considering routine x-ray examination of the chests of all their patients as a case-finding procedure. It would seem to be useful, also, in checking pneumothorax cases. Where there are large surveys to be made, as in our Department, it acts as a definite "screen" and represents a considerable saving of the taxpayers' money. Some lesions will, of course, be missed, but this happens with larger films as well. Improvement, however, is being made in interpreting these films, and a special viewer has been found helpful.

We are using photoroentgenography at present to x-ray a large number of patients from a district which has a high tuberculosis mortality rate; all eligible prenatal cases in our Department have been studied by this method since Jan. 1, 1941, and we contemplate using it on a large number of food handlers.

CONCLUSION

Miniature films made and interpreted by trained and experienced radiologists are destined to play an increasingly important rôle in the discovery of new cases of pulmonary tuberculosis.

ADDENDA

Since this paper was written, we have purchased our second 4 × 5 inch photoroentgen unit, which we have found to be considerably faster than the first one and which shows better detail in the films. Our second unit is operating on a mechanical rectified machine, producing very satisfactory films. The following technic is utilized: ordinary x-ray tube, focal spot 3.5, 36-inch distance, 1/5 of a second exposure time, 150 ma. of current, kv. range from 70 to 85 depending upon the thickness of the chest.

The General Electric X-ray Corporation has just perfected a stereoscopic attachment for these units, which utilizes a 4 × 10 inch film and gives a true stereoscopic effect. A special stereoscope is required to view these films, however. A thin Lysholm grid has been added to this unit and has improved the sharpness of the image. This new stereoscopic

assembly is destined to become popular in chest survey work.

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REFERENCES

DE ABREU, M.: Röntgen-photographia. Rev. Assoc. paulista de med. **9:** 313–324, December 1936.

DE ABREU, M.: Collective Fluorography. Radiology **33:** 363–371, September 1939.

DE ABREU, M.: Process and Apparatus for Roentgen Photography. Am. J. Roentgenol. **41:** 662–666, April 1939.

DEARING, W. P., AND TURNER, A. E.: Chest Fluorography with Portable X-ray Equipment on 35 mm. Film. Pub. Health Rep. **55:** 2369–2377, Dec. 27, 1940.

FELLOWS, H. H., AND ORDWAY, W. H.: Fluoroscopy versus Physical Findings in the Detection of Pulmonary Tuberculosis. Natl. Tuberc. Assn. Tr. **33:** 51–53, 1937.

HIRSCH, I. SETH: Utility of Fluorography. Radiology **36:** 1–11, January 1941.

JANKER: Die Leuchtschirmphotographie. Fortschr. a. d. Geb. d. Röntgenstrahlen **58:** 588–593, December 1938.

LINDBERG, D. O. N.: Suggested Modifications of Technique for Roentgen Photography. Am. J. Roentgenol. **41:** 867–869, May 1939.

PLUNKETT, ROBERT, E., AND TIFFANY, WILLIAM, J.: A Tuberculosis Control Program for Institutions in New York State Department of Mental Hygiene. Am. J. Pub. Health. **31:** 769–771, August 1941.

POTTER, H. E.: Roentgenography of Pulmonary Tuberculosis, with New Method for Group Surveys (Russell D. Carman memorial lecture). Minnesota Med. **21:** 763–768, November 1938.

POTTER, H. E.: Miniature Films in Chest Surveys. Radiology **34:** 62–65, January 1940.

POTTER, H. E., DOUGLAS, B. H., AND BIRKELO, C. C.: Miniature X-ray Chest Film. Radiology **34:** 283–291, 1940.

ULRICI, H.: Mit der Röntgenmusterung auf der Suche nach der unbekannten Tuberkulose. Deutsche med. Wchnschr. **65:** 869–871, June 2, 1939.

ZAKOVSKY, J.: Über ein neues Verfahren bei Schirmbildaufnahmen; Schirmbildaufnahmen im Mittelformat. Fortschr. a. d. Geb. d. Röntgenstrahlen **61:** 31–35, January 1940.

A Rapid Film Changer for Use in Contrast Angiocardiography[1]

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THE IMPORTANCE of contrast visualization in the study of the thoracic viscera has been adequately established. It has proved of considerable value in clinical diagnosis, as, for example, in the differentiation of aortic aneurysm and mediastinal tumor (1) and in the demonstration of shunts in congenital cardiac disease (2). The importance of the method in the study of pathologic physiology, however, is only partially appreciated. Interesting data were obtained by an investigation of the size of the right ventricle in emphysema (3). Unsuspected functional tricuspid insufficiency has been demonstrated in several cases of congenital heart disease (4). The size and arrangement of pulmonary vessels in certain diseases are better understood as the result of the report of Robb and Steinberg (5).

In a recent report (6) we discussed a multiple exposure method using fluorography. This method was developed because, in our experience, there were no satisfactory criteria in abnormal cases by which the right and left sides of the heart could be visualized regularly on two or three roentgenograms made at predetermined intervals. In our hands, circulation studies made by the usual methods not only were not helpful but often were misleading. Furthermore, when only one film of the right side was available for examination there was considerable possibility of error in interpretation. The "two-film" method was sufficient for anatomic delineation in certain cases but in physiologic studies it was quite inadequate.

In the fluorographic method, photographs of the fluoroscopic screen are made every half to three-quarters of a second during a period of ten to twelve seconds. The method is relatively inexpensive, is simple to use, and at the same time permits visual observation of the fluoroscopic screen during the photographic procedure. The main disadvantage lies in the coarse grain of the fluoroscopic screen which is recorded on the photographic image and is even more disturbing when the 35-mm. film is projected or magnified. Obviously the fullest detail would be achieved if the same rapidity of exposure could be obtained with direct roentgenography.

The following is a description of a simple, inexpensive apparatus designed for this purpose, with which eight roentgenograms of excellent quality can be produced. The apparatus consists of a wooden wheel 62 inches in diameter, mounted on an axle. Eight 10 × 12-inch cassettes are mounted radially. The wheel is turned by hand behind a lead screen in which there is a 10 × 12-inch opening. Each cassette passes behind this opening. An ordinary door stop serves to stop the wheel as each cassette arrives in position behind the opening in the lead screen. With practice, eight exposures can be made in ten seconds. It is easy to position the patient by preliminary fluoroscopy, one cassette being removed and replaced by a fluoroscopic screen held behind the opening in the lead screen.

Obviously the present apparatus is of the "homemade" type but, being so, is relatively inexpensive. It permits exposures every one and a quarter seconds. Errors occur which must be expected with hand operation. It would be better could roentgenograms be made every three-quarters of a second automatically. We believe that this can be accomplished by the use of a ball-bearing reinforced wheel, automatic rotation and automatic expo-

[1] From the Departments of Radiology and the Cardiographic Laboratory, The Mount Sinai Hospital, New York, N. Y. Accepted for publication in May 1941.

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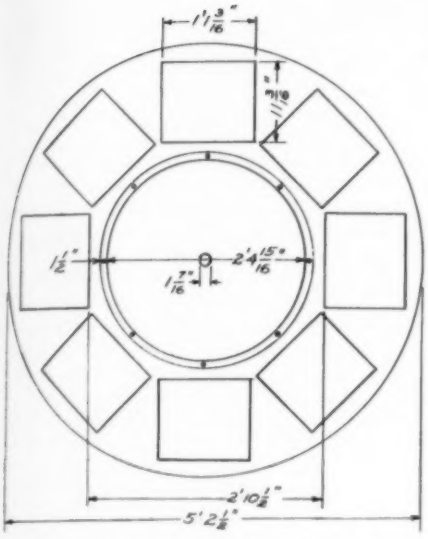

Fig. 1. Rapid film changer for use in angiocardiography.

sures being obtained by a Geneva drive geared to the wheel.

The present preliminary apparatus is being described in order to stimulate those investigators who may have been discouraged by the haphazard results obtained by the "two-film" method and who are disappointed with the detail obtained by the fluorographic method.

Note: Our profound thanks are due to the Picker X-Ray Corporation who had our present wheel built for us, and to Mr. J. Pfale of that company and Mr. E. R. Owen of the Du Pont Film Manufacturing Corporation for their many valuable suggestions. Also we wish to thank the Winthrop Chemical Company for supplying us with Diodrast solution 70 per cent so that these studies could be made.

1 East 100 St., New York, N. Y.

REFERENCES

1. STEINBERG, ISRAEL, ROBB, G. P., AND ROCHE, U. J.: Differential Diagnosis of Mediastinal Tumor and Aortic Aneurysm: Value of Contrast Cardiovascular Visualization. New York State J. Med. **40:** 1168–1177, August 1940.

2. GRISHMAN, A., STEINBERG, M. F., AND SUSSMAN, M. L.: Tetralogy of Fallot: Contrast Visualization of Heart and Great Vessels. Radiology **37:** 178–180, August 1941.

3. SUSSMAN, M. L., STEINBERG, M. F., AND GRISHMAN, A.: Contrast Visualization of the Heart and Great Vessels in Emphysema. In press, Am. J. Roentgenol.

4. GRISHMAN, A., STEINBERG, M. F., AND SUSSMAN, M. L.: Functional Tricuspid Insufficiency Demonstrated by Contrast Visualization. To be published.

5. STEINBERG, ISRAEL, AND ROBB, G. P.: Mediastinal and Hilar Angiography in Pulmonary Disease: Preliminary Report. Am. Rev. Tuberc. **38:** 557–569, November 1938.

6. SUSSMAN, M. L., STEINBERG, M. F., AND GRISHMAN, A.: Multiple Exposure Technique in Contrast Visualization of the Cardiac Chambers and Great Vessels. Am. J. Roentgenol. **46:** 745–747, November 1941.

CASE REPORTS

Ice Pick in the Superior Posterior Mediastinum for Eighteen Years[1]

JOSEPH J. LALICH, M.D.,[2] and GALEN M. TICE, M.D.[3]

Kansas City, Kansas

REPORTS OF aspirated bodies in the air passages are multitudinous; records of foreign bodies present for long periods in the lungs or mediastinum are less frequent. For this there may be two reasons: either the foreign body is immediately removed surgically, or the victim succumbs from pulmonary hemorrhage soon after the injury is sustained. Because of the long asymptomatic period in the presence of a foreign body in the superior mediastinum we consider this case sufficiently interesting to report.

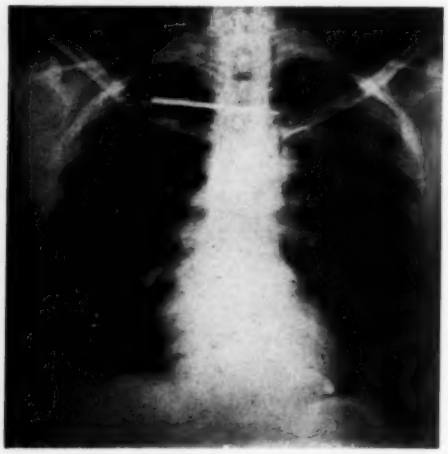

Fig. 1. Roentgenogram showing foreign body overlying upper chest structures.

Fig. 2. Lateral view showing relation of foreign body to fourth dorsal vertebra.

CASE REPORT

A colored man, thirty years old, entered the University of Kansas Clinic on June 29, 1939, complaining of cardiac palpitation and substernal pain. He had been well until four months previously, when the first attack of pain occurred as he was walking home from work. Since that time walking had always precipitated cardiac palpitation, which was followed by substernal pain and dyspnea. The past medical history revealed that the patient had a chancre on the glans penis in 1933, for which he received treatment. He had a chronic cough, during which he raised a greenish phlegm with difficulty.

The patient appeared well nourished and slightly dyspneic. Pulsation was visible in the suprasternal notch. The chest showed equal motility on the two sides. Roughened breath sounds were heard in the posterior hilar areas; pulmonary findings were otherwise normal. Cardiac rhythm was regular; the rate was 70. There was a faint systolic aortic murmur which was transmitted into the neck. The blood pressure was 170/120. A scar was observed on the glans penis, measuring 3 mm. in diameter. The Wassermann and Kahn tests were negative. Electrocardiogram showed relative insufficiency of the entire coronary circulation.

The diagnosis was cardiovascular syphilis, syphilitic aortitis, and hypertension. Continuous antisyphilitic therapy was given for one and one-half years.

Eleven months following his first visit to the clinic,

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the patient complained of persistent dull chest pain in the posterior left axillary region, exaggerated by stooping, exertion, or coughing. Cough had become more persistent but the quantity of sputum was slight. Examination of the chest revealed a friction rub in the left axillary area, with decreased vocal resonance in the left suprascapular region.

Fluoroscopic and roentgenographic examinations of the chest showed a stylet-like body measuring 11 cm. long, overlying the upper chest structures (Fig. 1). A lateral view (Fig. 2) led to the opinion that this lay in the anterior portion of the fourth dorsal vertebra. There was slight autolysis about the foreign body. The lung fields were essentially normal. There was no evidence of inflammatory reaction of the pleura. The aorta was moderately dilated and tortuous. The heart was within normal limits as to size, but the left ventricle showed greater development than the other chambers. Cardiac pulsation was forceful and regular. A metallic body 1 × 0.3 cm. was also seen on the tip of the acromion process (Fig. 3).

A dilated aorta in a person of this age suggests aortitis. The foreign body described lay in the posterior superior mediastinum and appeared to pass through the anterior portion of the fourth dorsal vertebra. When the patient was informed about the foreign body in his chest he recalled that he had been stabbed with an ice pick eighteen years previously. He has been followed for two years; in that interval the hypertension has improved slightly, the cardiac symptoms have disappeared, and he has maintained his weight. Since there is no x-ray evidence of pulmonary or pleural inflammation and the patient continues to remain asymptomatic, surgery has not been recommended.

DISCUSSION

Konjetzny (1) has enumerated acute and chronic hemorrhage, pulmonary and pleural abscesses, empyema, arterial aneurysm, pleural thickening, and bronchiectasis as the most common sequelae of shrapnel or gunshot wounds in the lung. Ulrich (4) concluded that shrapnel is non-irritating; it may either lie freely in the lung tissue, or the capsule which forms about the foreign body may not be demonstrable by x-ray. In the majority of reported cases of foreign body in the chest, intermittent hemoptysis or pulmonary abscesses developed, necessitating surgical intervention (5, 6, 9, 11, 13, 14). A few of the patients died years afterward from secondary causes, as cerebral abscess (Polayes and Zaldin, 7) pulmonary carcinoma (Luckow, 10; Sergent, 11), and tuberculosis (Lossen, 8), which the authors believed were attributable to the foreign body in the lung. Landsberg (12) reported an unusual case in which a sequestrum from one of the ribs pierced the lung tissues. Herxheimer's patient (13) expelled a metallic body during a paroxysm of coughing. Koetzle (14) reported the most unusual case, in which a piece of shrapnel which lodged in the lung emerged spontaneously from the skin.

The present case, in accordance with Kanert's conclusions (2), shows very little evidence of irritation from the metallic body in the mediastinum. No capsule or inflammation is demonstrable by x-ray in the pulmonary tissue. The lateral view, however, shows autolysis of the fourth dorsal vertebra.

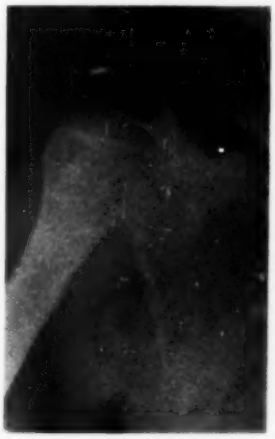

Fig. 3. Foreign body at tip of acromion process.

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REFERENCES

1. KONJETZNY, G. E.: Die chirurgische Behandlung der Lungensteckschüsse. Chirurg **11:** 825–829, Dec. 15, 1939.

2. KANERT, W.: Verletzungen durch Metallsplitter. Therap. d. Gegenw. **80:** 408–413, September 1939.

3. FINCK, C.: Proyectil de arma de fuego alojado en el pulmón derecho y extraído por neumotomía. Rev. mex. de cir., ginec. y cáncer **5:** 477–485, August 1937.

4. ULRICH, K.: Lungensteckschüsse und deren Folgen. Röntgenpraxis **7:** 145–156, March 1935.

5. LECHELLE, P.: Eclat d'obus intrapulmonaire. Abcès enkysté. Drainage permanent depuis sept ans.

Bull. et mém. Soc méd. d. hôp de Paris **51:** 446–447, March 18, 1935.

6. LILIENTHAL, H.: Shell Fragment in Lung: Removal after 15 Years. Mil. Surgeon **75:** 140–144, September 1934.

7. POLAYES, S. H., AND ZALDIN, S.: Cerebral Abscess, Report of a Case Following Impaction of Plate Glass in the Lung 12 Years Previously. Am. J. Surg. **24:** 178–180, April 1934.

8. LOSSEN, H.: Tuberkulöser Primäraffekt oder Lungensteckschuss? Röntgenpraxis **6:** 136–140, February 1934.

9. MOERSCH, H. J.: Removal of Piece of Shrapnel That Had Been in Lung for 15 Years. Proc. Staff. Meet., Mayo Clinic **8:** 421–422, July 12, 1933.

10. LUCKOW: Lungenkarzinom als Folge von Lungensteckssplitter 14 Jahre nach Verwundung. Ztschr f. ärztl. Fortbild. **30:** 702–703, Dec. 15, 1933.

11. SERGENT, E., DURAND, H., KOURILSKY, R., AND COUVE: Cancer primitif du poumon à type d'abcès chez un ancien blessé de poitrine conservant deux éclats restés inclus. Bull. et mém. Soc. méd. d. hôp de Paris **47:** 806–811, May 25, 1931.

12. LANDSBERG, F.: Uber Aufnahme von Rippensequestern in die Lunge. Virchows Arch. f. path. Anat. **277:** 781–787, 1930.

13. HERXHEIMER, H.: Postpneumonisches Empyem sechs Jahre nach Lungensteckschuss. Med. Welt. **3:** 1727, Nov. 30, 1929.

14. KOETZLE: Neue Beiträge zur Frage der Geschosswanderung. Aerztl. Monatschr., October 1929, pp. 303–308.

EDITORIAL

Howard P. Doub, M.D., Editor

John D. Camp, M.D., Associate Editor

Roentgen Dermatitis among Physicians

It is a fact that many physicians actually believe that they possess a natural ability to interpret roentgenograms and generally to use roentgen rays masterfully as diagnostic agents. Because of this erroneous conception and general lack of appreciation of the importance of special roentgenologic training, an ever increasing number of physicians, using their own x-ray machines, are injuring their hands severely enough to cause cancer. Lamentably, the main—if not the only—qualification to practise roentgenology manifested by the great majority of a group of 135 physicians injured by their own equipment seemed to be the possession of roentgenologic apparatus.

All informed physicians appreciate the value of roentgenologic procedures in all branches of medical and surgical practice, but many do not seem to recognize the difficulties entailed in the production of a roentgenogram of maximal diagnostic excellence, nor do they fully appreciate the tedious study and detailed training requisite to the intelligent interpretation of a roentgenogram. Worst of all, they do not seem to realize that there is a radical and fundamental difference between the ability of the roentgenologist and the non-roentgenologist to use roentgen rays adequately, appropriately, and safely. If this were not true, the incidence of injury in the two groups would be more equally divided than it is.

There is, unfortunately, no easy way to prevent the physician who "does a little x-ray work" from running the risk of injuring himself. With conditions as they are at present, anyone who can purchase an x-ray machine can practice roentgenology—in a limited way, it is true. With the machine as a start, so to speak, the acquisition and casual reading of a few textbooks with pictures are thought to be enough to round out the general practitioner into a journeyman roentgenologist, without further ado. This "training" may be supplemented in the unusual instance by a few hours of observation of the work of the specialist. "Unqualified" physicians already have bought x-ray equipment worth millions of dollars, and probably will continue to do so. Many of these physicians, as far as can be determined, are using the roentgen rays intelligently, safely, and well in their practices. Since modern x-ray equipment is as reliable and safe as engineering can make it, the whole remedy for roentgen-ray injuries hardly seems to lie in the further development of mechanical safety devices on roentgenologic apparatus.

The true remedy is the widest possible dissemination of knowledge concerning the dangers of roentgen rays in unskilled hands, and the widest publicity should be given to the adoption of the long-known measures of protection. It will probably do little good for roentgenologists to continue to present papers on roentgenologic risks to members of the national societies, who already know about such risks. Rather, the missionary work (for such it is) should be done by safety committees through local medical societies and their journals, since it is not the roentgenologist but the physician who does "a little x-ray work" who needs protection. E. T. L.

How Can We of Radiology Best Serve Our Country?

The splendid meeting of the Radiological Society of North America at San Francisco had just adjourned; many of its members were still en route to their homes and families when on the morning of Sunday, Dec. 7, 1941, we learned that Japan had pounced from the sky, like a wild leopard from the trees of the jungle, upon an innocent and unsuspecting victim—our national protective forces in Hawaii. Such a barbaric assault must necessarily have aroused the highest degree of resentment in the hearts of all. Our immediate reaction was expressed in such questions as: What can I do? How can I help? In what manner can I best serve my country as a radiologist in this crisis? Many of the members of our Society were already reserve officers; others were connected with the active military service. Their duties became evident since their manner of employment was already arranged through governmental provisions. There remains, however, a very large proportion of our membership not thus attached, who join with those members already in service in voicing the sentiments of our organization as follows:

"The Radiological Society of North America, in full cooperation with organized medicine, offers the government, which encompasses our homes, our cities, our states, and our country, the use of its experience and knowledge in the field of radiology. Through such specialized means the Society believes that it can best perform its patriotic duty and demonstrate its loyalty and love of country. As individual members we shall, naturally, exert every possible means of assistance, including our contributions to all worthy war-time causes, and our help in military and civilian defense."

Many of us remember World War No. 1 and the important rôle of radiology in that conflict. Although there were but few experienced radiologists, with scanty equipment, which was crude and difficult to handle, and though many obstacles existed, these pioneers in radiology rendered most valuable service. Their accomplishments serve as an incentive to us to duplicate their excellent work. With modern x-ray apparatus, with refined roentgenologic technic, and with many more experienced radiologists, a great job can and must be done.

One of our many duties is to aid in the specialized education of the younger men in the field of military radiology. A central organized body of radiologists cooperating with the government could draw up an outline of a course or courses to be conducted in our medical schools or hospitals for all desiring such instruction, but particularly for rotating interns and residents in radiology. This training obviously would be especially directed toward a knowledge of radiology as applied to the military expectancies for candidates to be inducted into radiologic service.

Naturally there are many problems relative to the status of those engaged in radiologic training as yet undecided by our government. For example: Will residents in radiology be permitted to complete their work? Will any provisions be made to replace them with new residents should they be called to service? Such information will, no doubt, soon be available, so that we of the radiological profession can serve our government to the fullest extent efficiently and intelligently.

There is need for radiologists in both the Army and Navy, and we therefore urge those of our members who are in a position to serve, to give every consideration to this necessity. Members of our society are urgently requested to read and digest carefully the editorial in the *Journal of the American Medical Association* for Dec. 27, 1941 (page 2254), entitled "A Call to the Medical Profession," and to co-operate fully in replying to the questionnaire contained therein. In this way it will be

practical to assign every radiologist to some form of duty, adding his experience and ability to the common cause in which we are all eager to unite, namely, the salvation of our homes and country. For the benefit of those directly concerned we quote from the editorial to which we have just referred: "A physician called by the Selective Service who has not enrolled or who is not on a reserve list obviously serves without a commission during the time that necessarily elapses before a commission is secured."

The dire calamity to our fellow countrymen and our possessions and the uncivilized manner of its perpetration have incited a war in which Americans are united as never before in a fixed and determined will to victory. The medical profession is doing its part toward a victorious conclusion. The radiological profession, as well as other highly specialized branches of medicine, is anxious and determined to give its services whenever and wherever the government deems best. Success will come only as the result of the efforts of all; each one of us has a vital part to perform and we regard it not only as a duty but as a privilege to exert our best efforts in so great a cause. It will be a hard pull, a long pull, but with our united strength we will attain the noble purpose of our efforts. Such a purpose is interwoven with that of our allies and is embodied in those sacred words so recently on our lips, as we observed the Christmas season: "PEACE ON EARTH TO MEN OF GOOD WILL." Toward this achievement the radiological profession is determined to exert every possible degree of energy.

Let us erect a militant radiological edifice, for which a strong foundation already exists, that shall stand as a blinding light to our barbaric enemies, a source of aid to the civilized nations of the world, and a glowing monument to posterity!

LEON J. MENVILLE, *President, Radiological Society of North America*

California Supreme Court Decision on the Ownership of Roentgen Films

S. W. DONALDSON, M.D.

Chairman, Medico Legal Committee
Ann Arbor, Michigan

The California Superior Court has rendered a decision regarding the ownership of roentgen films. Two previous decisions have been handed down, the first in Massachusetts, Whipple *v.* Grandchamp, (Mass.) 158 N.E. 270, and the second, McGarry *v.* J. A. Mercier Co., 272 Mich. 501, 262 N.W. 296. In the Massachusetts case the Court declared, in brief, that the roentgenograms were the property of the hospital and that, along with the report, they constituted a part of the hospital records. In the Michigan case, the defendant company had refused payment for professional services rendered an injured employee because the attending physician had not made frequent reports and had refused to deliver to them the x-ray films made incident to treating the patient. The physician had signified his willingness to have the films examined by any other physician or physicians if the films were not removed from his office. The Court held that "plaintiff was fully justified in refusing to surrender possession of the x-ray negatives. In the absence of an agreement to the contrary, such negatives are the property of the physician or surgeon who has made them incident to treating a patient."

In California the proprietorship of roentgenograms has come before the lower courts on two previous occasions, when the Los Angeles Municipal Court and the San Francisco Municipal Court have seen fit to render a decision that the films were the property of the roentgenologist.

The most recent Superior Court decision arose from a suit started by the patient to recover the amount of the fee paid for a gastro-intestinal and gallbladder examination. The request for the examination came from a referring physician, who was sent a report of the findings and who reviewed the films with the consulting roentgenologist. The patient demanded the films and a copy of the report and was told that the disposition of the report or permission to examine the films rested wholly with his physician. The patient took the matter to the Small Claims Court and won a decision. The roentgenologist and hospital involved appealed the case to the Superior Court of the State of California.

The findings of fact by the Court were that the plaintiff consulted a physician for treatment. For the purpose of aiding him in diagnosis for such treatment the physician directed the plaintiff to have certain x-ray examinations made. Arrangements were made with a roentgenologist at a hospital and it was shown that on certain dates the plaintiff had the x-ray examinations made and that the roentgenologist delivered to the plaintiff's physician a report of his findings, but not the films.

Within a month after the x-ray examination the plaintiff applied for life insurance. In the course of an examination for the purpose of determining his eligibility for insurance he was asked whether he had ever had x-ray examinations. When the plaintiff answered in the affirmative he was requested by the insurance company to authorize it to examine the films, which authorization he gave in writing. Upon receipt of this written request the hospital authorities and the radiologist refused to permit examination of the films by the insurance company. The agent of the insurance company was informed that these films could be shown only on the authorization of the physician who had originally requested that they be made. The plaintiff then asked the physician to give permission for the insurance company to examine the films but this request was refused. The patient himself then demanded possession of the films and this request was also refused.

The plaintiff had paid in advance for the x-ray examinations at the regularly scheduled charges and contended that, even though he had not been able to obtain possession of the films, no part of the payment had been refunded to him by the hospital or the radiologist.

It was shown that it is the custom and practice of the defendants to render no x-ray service except at the request of a physician attending a patient and that the charges made for the service of the roentgenologist include a report based upon his interpretation of films made during the examination. It was also shown that the defendants regarded films made during x-ray examinations as a part of the permanent records of the hospital and available for examination only at the request of the physician originally ordering them. The findings of the Court were that the plaintiff had contracted for the services of a roentgenologist and not for the purchase of the x-ray films.

It was the contention of the plaintiff that in failing to deliver to him, or to persons authorized by him, the films made during an x-ray examination, the defendants had failed to fulfill their contract and that he was entitled to a refund of money paid for the examination.

It was the conclusion of the Court that the defendants in making an x-ray examination and delivering a diagnosis had fully performed their contract. A further conclusion of the Court was that in the absence of a special agreement to the contrary, a hospital furnishing x-ray service for a fee contracts

only to furnish a diagnosis and a report from the findings of its roentgenologist and does not agree to sell or give possession of the x-ray films, nor does it agree to permit an examination of said films by the patient nor by any person or corporation whom he may authorize to examine them except the physician originally directing that said x-ray service be rendered. It was ordered by the Court that the judgment in favor of the plaintiff in the lower court be reversed.

In further discussion of the case it is worth while to call attention to the fact that in 1914 a committee selected from members of the American Roentgen Ray Society reported as follows: "That no report should be given to the patient except through the referring physician or surgeon. That patients are sent for consultation and diagnosis and are not entitled to plates or prints. Prints in the hands of patients lead to false interpretation, confusing opinions, multiplicity of advice and bad results." In 1920 the Radiological Society of North America adopted a resolution which reads, in part: "That it is the sense and judgment of this Society that all roentgenograms, plates, films, negatives, photographs, tracings or other records of examinations are hereby declared the exclusive property of the radiologist who made them or the laboratory where they were made." It is also of importance to note a portion of the opinion rendered in the McGarry v. Mercier case, in which the court said, "In the event of a malpractice suit against a physician or surgeon, the x-ray negatives which he has caused to be taken and preserved incident to treating the patient might often constitute the unimpeachable evidence which would fully justify the treatment of which the patient was complaining." This assertion by the court affirms the observations of radiologists made several years prior to the decision that prints in the hands of patients lead to false interpretation, confusing opinions, and multiplicity of advice.

This most recent decision, besides establishing the ownership of the films, also protects the interest of the referring physician in that it specifically designates him as the person to divulge information about his patient.

The court is also of the opinion that a roentgenologist enters into an implied contract to perform a service for the patient's physician and that upon completion of the service and notification by means of a report to the physician, the roentgenologist has then fully performed his contract.

326 N. Ingalls St.,
Ann Arbor, Mich.

Presentation of the Gold Medal to Dr. Edith Hinkley Quimby at the Twenty-Seventh Annual Meeting

The founders of the Radiological Society of North America in their far-seeing wisdom saw fit to provide a Gold Medal that those who serve the science of radiology conspicuously might be honored. Two such medals may be given each year but none need be given. There have been years in which there was found no one worthy of the highest honor that this Society can bestow.

This year our Society is honored in honoring one of its own members, who by her research has so materially aided all of us in our practical problems.

Dr. Edith Hinkley Quimby, scientist of eminence in the adjoining fields of physics, biology, and medicine; investigator of methods for, and dosage measurements of, radium and radon applications to the problems of therapy; elucidator of the intricacies of tissue dosage; student of the highly complex problems of skin reaction to radiation; careful explorer of the factors involved in producing different qualities of roentgen radiations and the effects of such varying qualities; scholarly interpreter of charts and figures; diligent guide in the problems of protection of workers and patients; effective teacher of radiation physics to both young and mature radiologists, and continuous, patient, and cheerful guide to all of us—

By the authority vested in me as Chairman of the Executive Committee, I hereby declare you Gold Medalist of 1941 and direct the President to present to you the Medal of the Radiological Society of North America.

ROBERT S. STONE, M.D.

Enrollment for Fourth Annual Refresher Series

The following analysis of the enrollment figures for the Fourth Annual Refresher Series held in connection with the San Francisco meeting has been prepared by Dr. Ira H. Lockwood, Chairman.

The total enrollment was 382, of whom 238 were members of the Radiological Society of North America and 14 members-elect. One-hundred and thirty non-members enrolled, of whom 12 were residents and internes, 9 were in military service, and 47 were non-radiologists.

CANADIAN ASSOCIATION OF RADIOLOGISTS

The Sixth Annual Mid-Winter Session of the Eastern Section of the Canadian Association of Radiologists was held in London, Ontario, on Jan. 5 and 6, 1942.

The formal opening session, presided over by President W. H. McGuffin, was held on the afternoon of Monday, Jan. 5, at Victoria Hospital, where members of the society had previously attended, at the invitation of the Minister of Health of Ontario, a meeting of the directors of the Ontario Cancer Clinics for a round-table conference on Carcinoma of the Breast. Following President McGuffin's call to order, papers were presented by Dr. W. J. Cryderman of Toronto on "The Radiological Evidence of the Importance of Hiatus Hernia," Dr. C. B. Peirce of Montreal on "Multiple Independent Neoplasms Occurring in the Same Individual," Dr. C. E. Vaughan of Hamilton on "Improved Roentgen Visualization of Placenta, Utilizing a Plastic Filter," and Dr. Digby Wheeler of Winnipeg on "The Tumour Clinic and the X-Ray Diagnostic Conference." A period devoted to brief case presentations and discussions concluded this session.

The Tuesday morning session was held at St. Joseph's Hospital. Dr. W. M. Gilmore of Stratford spoke on "Manipulation of a Limited Supply of Radium—A Demonstration and Discussion of Instruments, Applicators and Technique"; Dr. A. Jutras of Montreal on "The Upright Posture and Compression in Cholecystography with Special Reference to Floating Gallstones"; Dr. W. H. McGuffin of Calgary on "Lesions of the Thoracic Aorta"; Dr. M. R. Hall of Toronto on "Experience with Laminography." A special feature of this session was the Clinical-Radiological-Pathological Conference with Drs. F. S. Kennedy, L. D. Wilcox, H. O. Foucar, A. J. Grace, J. H. Fisher, F. W. Luney, and M. C. Morrison participating.

At the concluding session, held Tuesday afternoon at Queen Alexandra Sanatorium, the following papers were presented: "A Review of the X-Ray Survey of Chests in the Canadian Army" by Major G. T. Zumstein, R.C.A.M.C., Ottawa; "Experiences with the Selection of Recruits from the Standpoint of Chronic Non-tuberculous Disease" by Dr. P. M. Andrus of London; "Pneumonitis and Virus Pneumonia in Army Patients" by Major A. E. Broome and Capt. Arthur Valee, R.C.A.M.C., Petawawa; "Some Overseas Radiological Problems" by Dr. A. E. Childe of Montreal; "Deep X-Ray in the Treatment of Asthma" by Dr. R. C. Burr of Kingston; "The Radiographic Diagnosis of Silicosis" by Dr. D. W. Crombie of London.

The annual banquet and reports of committees were a most interesting part of the conference.

Arising out of the deliberations, the Association is entering into an agreement with the Royal College of Physicians and Surgeons of Canada, whereby radiologists who are considered qualified may be certified by the College. The question of the radiological services in small hospitals was thoroughly discussed and committees were appointed to bring in reports upon conditions existing in Eastern and Western Canada with suggestions as to the manner in which the public can best be served radiologically.

CENTRAL NEW YORK ROENTGEN SOCIETY

The Central New York Roentgen Society held its annual meeting in the Hotel Syracuse, Syracuse, N. Y., on Jan. 10, 1942. The speaker of the evening was Dr. John W. Pierson of Baltimore, whose subject was "Practical Consideration of Chest Conditions."

The following officers were elected for 1942: William J. MacFarland, M.D., Hornell, President; Thomas N. Sickels, M.D., Watertown, Vice-President; Carlton F. Potter, M.D., Syracuse, Secretary-Treasurer.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS

The newly elected officers of the Michigan Association of Roentgenologists are L. E. Holly, M.D., of Muskegon, President; A. L. Ziliak, M.D., of Bay City, Vice-President; E. M. Shebesta, M.D., of Detroit, Secretary-Treasurer.

CLINICAL CONFERENCE OF MID-WESTERN RADIOLOGISTS

The Sixth Annual Clinical Conference of Mid-Western Radiologists was held in St. Louis, Missouri, on Feb. 13 and 14, 1942, at the Chase Hotel. The Conference was sponsored by the St. Louis Society of Radiologists.

AMERICAN CONGRESS ON OBSTETRICS AND GYNECOLOGY

The American Congress on Obstetrics and Gynecology will meet in St. Louis, April 6–10, 1942. The Directors of the project believe that, notwithstanding the war situation, the Congress should be held at the stated time and are proceeding with their plans to make this an outstanding gathering. Inquiries may be addressed to the Central Office, 650 Rush Street, Chicago, Illinois.

Book Review

CANCER OF THE FACE AND MOUTH. DIAGNOSIS, TREATMENT, SURGICAL REPAIR. By VILRAY P. BLAIR, M.D., SHERWOOD MOORE, M.D., AND LOUIS T. BYARS, M.D., St. Louis. A volume of 599 pages with 260 illustrations and 64 plates. Published by The C. V. Mosby Company, St. Louis, 1941. Price $10.00.

It is an established fact that in the successful treatment of malignant neoplasms about the head, nothing is more important than early diagnosis. If cancers in this region are to be effectively controlled, there is unquestionably an urgent need for publications of an informative nature which, by presenting specific descriptions of the clinical appearance of precancerous and definitely cancerous lesions, will aid the student and general practitioner in the recognition of these tumors. Well adapted to meet this need is the text by Blair, Moore, and Byars, which consists of a well planned analysis and detailed account of the diagnosis, differential diagnosis, and treatment of epitheliomas involving the face, scalp, eyelids, and orbit, the external ear and auditory canal, the lips, mouth, and pharynx, the nasopharynx, nasal cavities, and sinuses; also malignant tumors affecting the jaws and salivary glands. There is here a wealth of information systematically and concisely arranged for study and reference, divided into nineteen chapters and profusely illustrated. There is much valuable information, also, to instruct and interest the specialist, since innumerable drawings to illustrate methods of plastic repair have been incorporated within the volume. Since a demand for a book of this type actually exists, this should give assurance to the authors that the idea on which it is based is sound.

With no intent to detract from the value of the book, it is to be expected that medical men of wide experience may take exception to some of the methods of therapy recommended for various neoplasms. Such a situation naturally exists, since the treatment of many of these cancers is still a controversial question. At all events, this book embodies the maturest conclusions of its authors, who are recognized authorities in this field of medicine. The series of sixty-four plates on operative technic, particularly stressing the reconstructive procedures employed by Doctor Blair, is excellent.

The Relationship of the Roentgenologist to the Physician and Surgeon[1]

LEON M. BOGART, M.D.

Flint, Michigan

Roentgen, when he discovered the x-ray in 1895, uncovered a hornet's nest. The doctor, secure in his fringe of scientific terms, was too close to the aura of empiricism to be jolted out of his toppling Galenic conception. Keen's "Surgery," published in the latter part of the 19th century, spoke of cholecystitis as being caused by tight lacing, but spoke very little of the disease itself. Tait, in the late seventies of the 19th century, doubted the wisdom of asepsis in surgery. Osler's edition of 1905 has little reference to x-ray. Surgeons abroad early recognized its value, for in 1896 reports of surgical pathological lesions were described with x-ray findings. In 1907, in Dr. DaCosta's "Surgery," little reference was made to x-ray in the text, but in a discussion rather extensive mention is made of possibilities, also the advisability of mixing bismuth with food to visualize the gastro-intestinal tract was discussed.

The mysterious ray, piercing the depth of tissues and recording different density, not only brought out the silhouette of bone, but emphasized the necessity of physical comparison of shadows in physiology as well as pathology. When Cannon and Williams first gave an opaque meal, the innermost secrets of eternally covered unknowns were blasted open to the curious gaze of the delving scientists, as though it were the secrets of the solid undercore of the earth made available for scientific observation. When early reports of x-ray burns and x-ray epithelioma became known, the destruction of the tissues became a hunting ground for the investigator and research worker, to turn the flood of destruction to the nihilist cell—the cancer cell.

From the little flicker of the first gas jet vacuum tube emitting the unknown ray that man made and controlled, grew the precise tabulator of pathological processes of today.

Friedenwald, many years ago, brought to the attention of the roentgenologist the irregularity of the mucosa in gastric ulcer, and now this sign is coming into prominence with the improvement of the technique of rugæ visualization. The laboratory evaluation of gastric ulcer diagnosis has been greatly superseded by the x-ray findings, but here the surgeon must remember that often one is apt to read into the plate non-existent pathology.

It is indeed a far cry from the full hour exposure required in the early days of x-ray to the present split second exposure with its exact delineation and clarity. The art of physical diagnosis and great personal error has largely given way to the penetrating ray. Yet we, as physicians and surgeons, by relying too much upon the trained interpretation of the x-ray findings, must not lose sight that the personal equation is not to be discounted, for the radiologists differ between themselves just as frequently as the physicians or surgeons. The plate is inanimate—the human mind reads its signs.

One of the most useful branches of radiologic technic, and one probably requiring most judgment, fluoroscopy has lent itself to be the most blatant instrument of the charlatan. Newspaper and radio advertisements are full of misconceptions of fluoroscopic values and the public is misled as to its possibilities. All of us, I am sure, deplore its misuse and hope the public can be educated to its limitations.

The importance of the x-ray in the diagnosis of tuberculosis and as a check-up of its therapeutics has been proved invaluable. The detection of metastases and emboli is another chapter of scientific detection greater than fiction. Of course the oldest service for which x-ray was used was the diagnosis of bone pathology and perhaps it is the one fraught with the most danger to the surgeon, because of the perfection expected in the treatment of fractures. The measurements and comparisons which the student of yore was taught are entirely disregarded by him now, yet in my judgment not to be discarded, for if length, alignment, and natural contour be taken in consideration, especially in the young, seeming faulty position of bone fragments are still molded into position as in the days antedating the x-ray. It is noteworthy that the attending physician only too often expects the roentgenologist to be the all-round specialist of interpretation, a glorified scientific soothsayer, which, of course, is flattering but leads to a yoke of dependence.

The flat plate herring-bone appearance of acute ileus or the telltale gas bubble in a subphrenic abscess, with the characteristic elevation of the dia-

[1] This article is of such pertinent interest to radiologists that the American College of Radiology has obtained permission to reprint it from the *Journal of the Michigan State Medical Society*, in which it first appeared, in December 1941. It was read March 18, 1939, before the Michigan State Roentgenological Society and again, by request, on May 21, 1941, before the Third Annual Fracture Clinic, given under the auspices of the Regional Fracture Committee of the American College of Surgeons and the Genesee County Medical Society, at Hurley Hospital, Flint, Mich.

phragm admit of no dispute in the diagnosis if taken in conjunction with the history and clinical course. The pathognomonic appearance of pencil-like narrowing in regional ileitis and many other positive findings of the x-ray form the bulwark of the diagnostic aids to the surgeon. Lesions of the large bowel or the stomach need more than ordinary acumen to diagnose unless definite pathologic size has developed. The surgeon expects too much when he looks to the roentgenologist to find the above-mentioned lesions in the initial stages, and negative findings should not deter the surgeon from proceeding with an exploratory operation. It is desirable to be able to localize early stages which do not show gross changes, and careful and minute study will, in many instances, detect changes in the physiologic contour brought about by the microscopic changes. The contrast obtained by forced gas distention of the bowel lumen has made many early lesions possible of detection. Even the etiological factor can be told within a certain degree of accuracy, due to the predilection of specific pathologic lesions for certain parts of the alimentary tract or bones.

We have to recognize that frequency of x-ray determinations does something to the end of the fractured bones, which retards the formation of callus. X-ray signs of bone dissolution, destruction and regeneration require knowledge of normal anatomy and physiology first, and sequence as well as regional pathology. Early pathologic changes become apparent to the skilled roentgenologist, as an irritable duodenum or pylorus may be recognized before full clinical symptoms of gastric ulcer appear, or an impending Sudeck's syndrome may be prognosticated by the early and persistent atrophy of bone.

To Rowntree and Abel, Cole and Graham, Swick and others, we owe the demonstration of the selective absorption of radio-opaque dyes given orally or intravenously and its use magnificently demonstrated in their widespread application. It is not necessary to remind you of opaque substances introduced through the ureters and per urethra into the bladder and the introduction of an opaque solution into the bladder for determination of bladder malignancies, or as the author lately used it in determination of ruptured urinary bladder (2). The use of radio-opaque oils or dyes to visualize spinal lesions and vascular pathology has been widely reported, requiring great skill and co-operation of roentgenologist and surgeon. The introduction of gas for ventriculograms also needs the teamwork mentioned above, and the use of ethylene instead of air seems to be gaining favor. The removal of the opaque dyes or oils used is of concern to both roentgenologist and surgeon, and is of great importance to the patient. The surgeon must not forget that microscopic changes do not manifest themselves in an x-ray plate; therefore, osteomyelitis, malignancies, or early bone deposits are not recognized in the early initial stages, and when negative to x-ray must not be dismissed as absent. Localization of foreign bodies on the plate does not always spell a spectacular removal, for I admit many difficulties that I had to cope with, even after excellent x-ray localization.

I can only allude to the brilliant chapter written by roentgenology in the field of therapeutics, especially deep x-ray in pre- and postoperative care of malignancies, as well as the direct attack of the lesion. Many enthusiastic reports in the treatment of acute regional infections have come to the fore, especially in acute postoperative parotitis or thrombophlebitis.

Controlled injection of radio-opaque media into fistulous tracts as well as the visualization of the biliary tract and detection of hidden duct stones by means of the x-ray on the operating table is being put to more frequent use.

The physician and surgeon must educate the laity that a roentgenologist is not a photographer of structures. We know that the x-ray plate is a record of the normal and abnormal anatomy and physiology; its deciphering requires skill and training, requiring a great deal of time and perseverance.

Baetzer and Waters (1) state that the roentgenologist has four inseparable friends, the anatomist, pathologist, internist, and surgeon, and I wish to add a fifth one, the physiologist. With them his work rises or falls. The physician and the surgeon should not shed their responsibility and expect the roentgenologist to make the diagnosis for them. The roentgenologist should be considered a highly skilled physician with whom his colleagues co-operate and co-ordinate as one of the important highways to reach the destination of a workable diagnosis and possible cure, and not the sun around which the medical and surgical diagnosis revolves.

REFERENCES

1. BAETZER and WATERS: Injuries and Diseases of the Bones and Joints. New York: Paul B. Hoeber, 1927.

2. BOGART, L. M.: Rupture of the Urinary Bladder. Am. J. Surg. **23**: 442, March 1934.

RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please cooperate with the Editor by supplying information to keep these notices accurate and up to date? Please send information to Howard P. Doub, M.D., Henry Ford Hospital, Detroit, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Building, Syracuse, N. Y.

American Roentgen Ray Society.—Secretary, C. B. Peirce, Royal Victoria Hospital, Montreal, Canada.

American College of Radiology.—Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual Meeting, 1942, Atlantic City, N. J.

Section on Radiology, American Medical Association.—Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual Meeting, 1942, Atlantic City, N. J.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Joseph D. Coate, M.D., 434 Thirtieth St., Oakland.

Los Angeles County Medical Association, Radiological Section.—Secretary, Donald R. Laing, M.D., 65 N. Madison Ave., Pasadena. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Secretary-Treasurer, L. Henry Garland, M.D., 450 Sutter St., San Francisco. Society meets annually during annual meeting of the California Medical Association.

San Francisco Radiological Society.—Secretary, J. Maurice Robinson, M.D., University of California Hospital. Meets monthly on third Thursday at 7:45 P.M., for the first six months at Toland Hall (University of California Medical School) and for the second six months at Lane Hall (Stanford University School of Medicine).

COLORADO

Denver Radiological Club.—Secretary, Edward J. Meister, 366 Metropolitan Bldg. Meetings third Friday of each month at the Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary-Treasurer, Max Climan, M.D., 242 Trumbull St., Hartford. Meetings bimonthly, on second Thursday. Place of meeting selected by Secretary.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, Walter A. Weed, M.D., 204 Exchange Building, Orlando. The next meeting will be at the time of the annual meeting of the Medical Association of Florida, April 13–15, 1942, at Palm Beach.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, Robert C. Pendergrass, M.D., Prather Clinic Bldg., Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—Secretary, Chester J. Challenger, M.D., 3117 Logan Blvd. The Society meets at the Palmer House on the second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Earl E. Barth, M.D., 303 E. Chicago Ave., Chicago.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, Methodist Hospital, Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Joseph C. Bell, M.D., 402 Heyburn Bldg., Louisville. Meeting annually in Louisville, third Sunday afternoon in April.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society. Next meeting, New Orleans, April 1942.

Shreveport Radiological Club.—Secretary-Treasurer, W. R. Harwell, M.D. Meetings monthly on the second Wednesday, at the offices of the various members.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Walter L. Kilby, M.D., 101 W. Read St. Meetings are held the third Tuesday of each month.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave., Detroit.

Michigan Association of Roentgenologists.—Secretary-Treasurer, E. M. Shebesta, M.D., 1429 David Whitney Bldg., Detroit. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—Secretary, John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. Meetings quarterly.

MISSOURI

The Kansas City Radiological Society.—Secretary, P. E. Hiebert, M.D., 907 North Seventh St. (Huron Bldg.), Kansas City, Kansas. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—Secretary, Wilbur K. Mueller, M.D., University Club Bldg. Meets on fourth Wednesday of October, January, March, and May, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—Secretary, D. A. Dowell, M.D., 816 Medical Arts Bldg., Omaha. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society (Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island).—*Secretary,* Hugh F. Hare, M.D., Lahey Clinic, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. J. Perlberg, M.D., Trust Co. of New Jersey Bldg., Jersey City. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo Harrington, M.D., 880 Ocean Ave. Meetings held the fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gianfranceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Ray Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Paul C. Swenson, M.D., Presbyterian Hospital, New York, N. Y.

Rochester Roentgen-ray Society.—Secretary, S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meeting with State meeting in May, and meeting in October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, L. A. Nash, M.D., St. John's Hospital, Fargo. Meetings by announcement.

OHIO

Ohio Radiological Society.—Secretary, J. E. McCarthy, M.D., Cincinnati. The next meeting will be held at the time and place of the annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, J. O. Newton, M.D., 13921 Terrace Road, East Cleveland. Meetings at 6:30 P.M. at the Mid-day Club, in the Union Commerce Bldg., on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*Secretary-Treasurer,* Justin E. McCarthy, M.D., 707 Race St. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport. The Society meets annually; time and place of next meeting will be announced later.

The Philadelphia Roentgen Ray Society.—Secretary, Barton R. Young, M.D., Temple University Hospital, Philadelphia. Meetings held first Thursday of each month at 8:15 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22nd St., Philadelphia.

The Pittsburgh Roentgen Society.—Secretary-Treasurer, Harold W. Jacox, M.D., 4800 Friendship Ave., Pittsburgh, Pa. Meetings are held on the second Wednesday of each month at 4:30 P.M., from October to June, at the Pittsburgh Academy of Medicine, 322 N. Craig St.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Malcolm Mosteller, M.D., Columbia Hospital, Columbia. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, Franklin B. Bogart, M.D., 311 Medical Arts Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—Secretary-Treasurer, L. W. Baird, M.D., Scott and White Hospital, Temple.

VIRGINIA

Virginia Radiological Society.—Secretary, Charles H. Peterson, M.D., 603 Medical Arts Bldg., Roanoke.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Kenneth J. Holtz, M.D., American Bank Bldg., Seattle. Meetings fourth Monday of each month at College Club, Seattle.

WISCONSIN

Milwaukee, Roentgen Ray Society.—Secretary-Treasurer, Irving I. Cowan, M.D., Mount Sinai Hospital, Milwaukee. Meets monthly on first Friday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

CANADA

Section on Radiology, Canadian Medical Association.—Secretary, W. J. Cryderman, M.D., Medical Arts Bldg., Toronto.

Section on Radiology, Ontario Medical Association.—Secretary, W. J. Cryderman, M.D., 474 Glenlake Avenue, Toronto.

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, A. D. Irvine, M.D., 540 Tegler Bldg., Edmonton, Alberta.

La Société Canadienne-Française d'Eléctrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meetings are held the third Saturday of each month, generally at the Radium Institute, 4120 East Ontario Street, Montreal; sometimes, at homes of members.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meetings are held monthly.

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Body Section Roentgenography as a Diagnostic Aid to the Otolaryngologist. Sherwood Moore and Alfred J. Cone. Surg., Gynec. & Obst. **72:** 514–522, Feb. 15, 1941.

The authors review briefly the history of body section roentgenography, known variously, and in general indiscriminately, as stratigraphy, planigraphy, tomography, and laminagraphy. For their own clinical work they use the laminagraph designed by Kieffer (described by him in Am. J. Roentgenol. **39:** 497, April 1938), which differs from other apparatus for similar purposes in that it combines all the mechanically possible coordinate movements of tube and film, as far as known, and makes possible their variation as desired.

In chest examination, cavities and consolidation in the lungs have been found by means of laminagraphy which were not apparent roentgenoscopically or in conventional films. The location, size, and physical characteristics of pulmonary cavities can be determined and the tracheobronchial tree can be clearly shown.

In study of the paranasal sinuses, where the problem of superimposed structures has been a troublesome one, laminagraphy has proved of great advantage. In examination of the ethmoid cells laminagrams reveal the size, position, extensions, anomalies, and pathological states far beyond anything possible with standard x-ray procedures, however extensively they may be carried out. This is also true of the sphenoid group both in anteroposterior and lateral projections. The conventional films of the maxillary sinuses generally suffice, but in an occasional case a pathological condition is revealed in the laminagrams which was entirely unsuspected even when contrast media were employed. Alterations in the auditory canals are demonstrated by laminagraphy, and the condition of the articulation of the mandible with the temporal bone can be established by this method when it is impossible to do so with conventional films since this joint is heavily overlaid by the zygomatic process and other bony structures. Deformities, erosion, and fractures of the condyle and glenoid fossa have many times been revealed, and the laminagraph has proved of great value in the diagnosis and treatment of the "temporomandibular syndrome." The larynx can also be investigated to great advantage (see, for example, Howes: Radiology **33:** 586, 1939).

The authors attribute the value of paranasal sinus laminagraphy to the information which it gives in showing variations in cell development. Interpretation of varying densities of individual cells, they admit, may remain controversial. The method should supplement conventional roentgenography and not be regarded as a substitute for the latter.

Reproductions of laminagrams illustrate the text.

THE CHEST

Tuberculosis in the Silicotic Subject. Leroy U. Gardner. Minnesota Med. **24:** 633–637, August 1941.

Certain American clinicians have been questioning the classical concept that a high tuberculosis rate is an essential part of the picture of silicosis. They point out that the roentgenographic patterns that have been described as characteristic of tuberculosis are too often unassociated with either pathognomonic symptoms or the presence of acid-fast organisms in the sputum to warrant such an assumption. The author believes this departure from the accepted beliefs to be fallacious, and presents evidence to show why some investigators have come to question the rôle of tuberculosis in determining the ultimate fate of the silicotic subject.

The original concept is founded largely upon the findings of the Miners' Phthisis Bureau of the Union of South Africa, which showed the presence of tuberculosis in approximately three-fourths of the silicotic gold miners coming to autopsy. Figures based on other surveys of industries producing dusts of high silica content are in substantial agreement.

Experimentally it has been found that the local injection of silica particles into animals produces a type of necrosis which is particularly favorable to the growth of the tubercle bacillus.

The anatomical forms of tuberculosis encountered in silicotic lungs can be comprehended in four categories: (1) the primary complex, including tubercles in the pulmonary parenchyma and the tracheobronchial lymph nodes; (2) typical reinfection tuberculosis, usually located in the upper third of the lung; (3) tuberculosilicosis, a very chronic form which constitutes the commonest manifestation of the infection; (4) acute perinodular tuberculosis, a rare form.

So-called *primary tuberculous infection*, if acquired during childhood, probably has little significance in silicotic individuals. Too few of these foci contain tubercle bacilli at the age of industrial employment. The lymph node infections, on the other hand, may persist longer, and it is conceivable that with the accumulation of silica reactivation might occur with resultant ulceration into a bronchus and dissemination into the lung.

If a first infection is acquired later in life, after the silicosis has already developed, an acute reaction is to be expected, similar to that observed in animals.

Reinfection tuberculosis of typical character, located in one or both pulmonary apices, occasionally appears in persons with slight degrees of silicosis or possibly in men whose dust reaction is old and no longer active.

Tuberculosilicosis is the most common form. Localized areas of massive fibrosis occur, situated usually in the upper lobe, though they may occur anywhere and are often bilateral. In typical cases there is a background of generalized silicotic nodulation, but not infrequently the nodules may be difficult to discern because of contraction of the lung and superimposed emphysema. Such reactions are extremely chronic and serial films may reveal little change for several years. Owing to the density of these lesions, over-exposures may be necessary to detect cavities roentgenographically.

Anatomically the lesion of silicotuberculosis is characterized by several unique features not seen in other manifestations of tuberculosis. The involved area is sharply defined and stony hard; usually there are nodular collections of scar tissue embedded in a matrix of similar appearance. There is usually evidence of an obliterative endarteritis, as a result of which focal areas of anemic necrosis may be present. Other portions of the lung are invariably emphysematous. The sputum tends to remain negative till late in the disease.

Acute perinodular tuberculosis is of rare occurrence, being observed mostly in young subjects. Later, the nodules appear less clean cut and show a fuzzy contour at the periphery. Tubercle bacilli are usually found in the sputum. The patient appears toxic.

Diagnosis in those cases with a chronic conglomerate lesion and dyspnea, but with no symptoms suggestive of infection, is very difficult. A lesion which changes appreciably in a year is always suspicious. It is doubtful whether the advanced case will benefit from sanitarium care; the time for effective treatment is at the moment when conglomeration first occurs.

Prevention rather than treatment should be the objective.

PERCY J. DELANO, M.D.

Pulmonary Tuberculosis of Hematogenous Origin. C. Gamna. Minerva med. **1**: 477–481, May 18, 1941.

This is a lecture with presentation of one case. The author admits there is great difference of opinion about this lesion. He adds nothing new.

E. T. LEDDY, M.D.

Visualization of Cavities in Post-Thoracoplasty Lungs: Preliminary Report. J. L. Leon, H. Green, and C. A. Serbst. Dis. of Chest **7**: 274–280, August 1941.

The authors have studied 18 patients in an effort to determine cavity persistence after various types of collapse therapy by using the cavity contents and the shifting fluid level to determine its presence. Sedatives are prescribed to prevent cough, and after sputum has accumulated in the cavity during the night, upright and tilt films are taken. The patient then attempts to expectorate as much as possible and the films are repeated. A shifting fluid level is taken as the criterion for the presence of cavity. A cavity could thus be demonstrated in 7 out of the 18 cases, while ordinary films were inconclusive.

WM. H. GILLENTINE, M.D.

Collapse Therapy in Moderately Advanced Tuberculosis: Inquiry into Case Selection and Statistical Study of End Results. K. M. Soderstrom. Am. Rev. Tuberc. **44**: 173–182, August 1941.

In a study of cases of moderately advanced pulmonary tuberculosis at Trudeau Sanatorium, New York, the results of treatment in 201 cases in which some form of collapse therapy was used were compared with the outcome in an equal number having no form of collapse. An attempt was made to evaluate the results without bias, although the author realizes that there is no method at present by which a statistically sound approach to the problem can be made. Those patients who did not receive collapse therapy showed much better morbidity and mortality rates than those who did. This would seem to indicate that cases subjected to collapse procedures were properly selected. The important discovery in this study, however, was the finding that collapse, when indicated, is of insufficient value to the individual to make up for what he does not possess in intrinsic resistance. Further studies along this line are recommended. L. W. PAUL, M.D.

Precise Localization of Pulmonary Abscesses: The "Spot" Method. Coleman B. Rabin. J. Thoracic Surg. **10**: 662–671, August 1941.

The chief difficulty with all methods previously described for localizing lung abscesses is the transferring of the knowledge gained from roentgen examination to the operative field. In order to overcome this difficulty the author has devised a method which consists essentially in placing a colored radiopaque material in the intercostal space in the region of the abscess.

The approximate position of the abscess is first determined by roentgenography, the usual posteroanterior and lateral views, as well as both right and left oblique exposures, being made. A mixture of 0.2 c.c. each of 0.5 per cent aqueous methylene blue and 40 per cent lipiodol is placed in a tuberculin syringe to which a short beveled needle is attached and after local anesthesia has been obtained the needle is inserted down to the rib, at the point determined from the films or, if the abscess is visible fluoroscopically, at a point directly over it, at its nearest distance from the surface. The needle is directed upward along the rib until its upper edge is felt and is then inserted an eighth of an inch farther. The mixture is now injected, supposedly into the intercostal muscle. The syringe is detached and withdrawn and a second syringe containing methylene blue is attached to the needle. As the needle is withdrawn the methylene blue is injected into the soft tissues, thus leaving a colored tract out to the skin.

A second set of films is now made, duplicating the original set. If the abscess is located medially, oblique views need not be taken in either instance, but if the abscess is located laterally these are necessary to obtain its correct relationship to any definite rib and to determine whether the lesion is more anterior or posterior. The second set of films will show readily the location of the lipiodol in relation to the abscess, and the rib to be resected can be determined. The surgeon can follow the methylene blue down to the rib and can go directly in, up or down, as indicated by the films. No rib counting is necessary.

The lipiodol must be in the intercostal muscle to keep it from diffusing out too far. A little practice with the method should make it possible for the surgeon to locate all lung abscesses with little difficulty.

H. O. PETERSON, M.D.

Some Points of Diagnostic Importance in Primary Carcinoma of the Lung. G. C. Guarnerio and F. Cambria. Minerva med. **1**: 389–396, April 20, 1941.

The authors discuss in detail 9 cases of primary carcinoma of the lung in which the clinical diagnosis was substantiated by postmortem examination. They emphasize that in addition to those cases with pulmonary symptoms there are some which present no local symptoms whatever, but are detected solely through some focus of metastasis. They correctly evaluate the importance of roentgen examination of the chest and of bronchoscopy. In spite of all methods of examination, however, with our present knowledge there will be an occasional obscure case, the true nature of which will remain unknown until necropsy.

E. T. LEDDY, M.D.

THE DIGESTIVE TRACT

Some Remarks Concerning the Early Diagnosis of Carcinoma of the Stomach. Mario Buisson. Minerva med. **1**: 377–389, April 20, 1941.

The author reviews the subject of the early diagnosis of gastric carcinoma—a theme presented at the International Congress of Gastro-enterology—with special reference to the work of Gutmann. The clinical, laboratory, and roentgen findings in the various types of cancer of the stomach are analyzed by the author from Gutmann's point of view and their relative importance is evaluated. Even though a precise diagnosis of early gastric cancer is generally impossible, the roentgenologic findings are of the greatest importance in giving a clue to the nature of a lesion which can be proved only by microscopic examination. E. T. LEDDY, M.D.

Concomitant Gastric and Duodenal Ulcers. G. Fregonara. Minerva med. **1**: 49–56, Jan. 12, 1941.

After a brief discussion of twelve theories of the causation of ulcer and its symptomatology, the author presents his own experience. In 1,100 cases of ulcer, there were 50 instances of simultaneous gastric and duodenal ulcer, and in one case a duodenal ulcer was associated with two gastric ulcers. In 5 cases complete operative confirmation of the diagnosis was obtained. The author feels that roentgen studies are more accurate and reliable than any other method of investigation and illustrates the findings in 9 cases. The duodenal lesion, according to radiologic examination, in the author's series of concomitant gastric and duodenal ulcers, was in the bulb along the lesser curvature in 25 instances, juxtapyloric in 12, and mid-bulbar in 11. In the stomach the commonest location was the lesser curvature (14 cases), next the posterior wall, and then the antrum.

The author points out that in so-called recurring

cases of ulcer the possibility of double ulcer should be seriously considered. E. T. LEDDY, M. D.

Cholelithiasis in Newborn Infants. George R. Spence. Arch. Pediat. **58:** 479–481, August 1941.

Following the exhaustive work of Alfred Potter (Surg., Gynec. & Obst. **46:** 795, 1928) which contradicted the view then commonly held that gallbladder disease in infancy and childhood is a distinct rarity, many workers have added authentic cases to the literature substantiating his contention. Potter himself has collected 25 additional cases and with others, collected by various men, was able, in 1938 (Surg., Gynec. & Obst. **66:** 604, 1938) to present a grand total of 432 cases of gallbladder disease in infancy and childhood. Sobel, among other authors, has added to the list, which is now in excess of 450. In Potter's 1928 series, 62.3 per cent of the cases showed cholelithiasis with or without cholecystitis.

A case of cholelithiasis in a newborn child is recorded here. The infant was delivered with no great difficulty but did not respond well to stimuli following delivery and died six hours later. No jaundice was noted. The cord blood gave four plus Wassermann and Kahn reactions. Necropsy revealed uric acid nephrolithiasis, intracranial hemorrhage, partial fetal atelectasis, and cholelithiasis. The gallbladder contained 10 c.c. of soapy, green bile. Nine calculi, composed mainly of bile pigment and varying in size from $1 \times 0.25 \times 0.3$ cm. to mere granules, were found. Some of the smaller stones were in the cystic duct. No gross obstruction or atresia of the ducts was present. There was no evidence grossly or microscopically of inflammation of the mucosa. PERCY J. DELANO, M.D.

THE SKELETAL SYSTEM

Considerations Relative to Rachitis Tarda. N. Goormaghtigh and C. Hooft. Rev. belge sc. méd. **13:** 281–304, July-August 1941.

The authors review the history of a girl of sixteen presenting the cardinal findings of rachitic changes in the bones and mental as well as physical retardation, with death from uremia which appeared to be the end-stage of a chronic nephritis.

The patient showed evidence of spastic paraplegia and some degree of fever was continuously present. Marked hypersensitivity was also evident; the child cried out when touched. On examination a spontaneous fracture of the right femur was discovered; and also a mass over the left tibia. Subsequently masses appeared over both humeri. Other findings included a general state of inanition and marked under-nutrition.

In addition to the spontaneous fracture of the right femur with marked over-riding of fragments, examination revealed a fracture of the left fibula, swelling over both wrists, a rachitic rosary, and a Harrison's sulcus. Dentition was normal.

The roentgenologic findings included generalized osteoporosis; a honeycombed appearance of the metaphyses; a widening of the epiphyseal lines of the long bones, with cupping in a cupola fashion; a raggedness and "fringing" in some of the epiphyses (*une image en franges*). The diaphyseal cortex was very thin; it was often reduced to a line, scarcely visible, and sometimes even this line disappeared. This atrophy was most marked at the level of the femoral fracture and in the middle of the right humerus. The cranial bones were very thin. There was a fracture in the left tibia.

The possibility of an osteitis cystica was considered, but the blood calcium and phosphorus findings did not bear out such a conclusion. The occurrence of a terminal nephritic state, a common accompaniment of late rickets, suggested the latter diagnosis.

Mention is made of the fact that this patient presented findings much like those observed in cases of hunger osteopathy described, particularly in 1919–21, in Austria and Germany.

At autopsy, the following were outstanding observations: extreme brittleness of all the long bones; slight curvature of both humeri; fracture of right femur; enlargement of the epiphyses; atrophy of the cortex of the long bones; subacute glomerulonephritis.

The enlargement of the epiphyseal cartilages and the presence of chondromatous nodules in the juxta-epiphyseal areas, and even in the epiphyses, are characteristic of a rachitic process. Looser has described this exuberance of cartilaginous tissue in "late rickets"; Parsons in "renal rickets." These heterotopic islands give rise to enchondromas and even cysts. Juxta-epiphyseal osteoid tissue, so abundant in the florid form of infantile rickets, was slight here, as is the rule in late rickets. Enchondral ossification was greatly reduced; only exceptionally did the chondromatous islets branch out into thin lacunae of ossification.

Under a thin and somewhat fibrous periosteum the corticalis of the metaphysis was reduced to a thin layer. It was resorbed by osteoclasts and retarded by the inadequacy of its osteoblastic component.

In the region of the fracture site in the femur, the rarity of the lacunae of Howship and of osteoclasts, the cleanness of the edges of the osseous bridges, surrounded by a thin bed of decalcified tissue, and the regularity of the haversian canals exclude any decisive intervention by osteoclasts. This is corroborative of the opinion of Schmidt as to the mechanism of cortical atrophy in late rickets. The presence of decalcified tissue of osteoid character at the peripheries of the concentric lamellae is indicative of the gradual loss of their calcium salts (halisteresis).

The authors enter at some length into theories of ossification and processes which may arrest or alter the transformation of cartilage into bone. The type of decalcification found in the microscopic specimens studied here seems consistently to accord with current views as to the mechanism of late rickets.

The question is raised as to whether the osteoporosis was due to a vitamin D deficiency: the authors point out that while enchondral ossification responds to a correction of nutritional deficiency, osteoporosis does not. They likewise take up the question of the interrelation of vitamin C deficiency with florid rickets: in their opinion, late rickets may well be due to a combined lack of calcium, phosphorus, vitamins D and C, and of fats. Vitamin C deficiency and a poverty of calcium and phosphorus may be responsible for osteoporosis and for the spontaneous fractures.

Late rickets is contrasted with osteomalacia; the latter remains obscure as to etiology, but in several cardinal points appears well demarcated as to *genre* from late rickets.

As to the question of influence of the nephritic state on the osseous changes in the case recorded, the authors state that renal impairment tends to produce phosphate retention; the threshold for phosphate elimination, of which Brull has demonstrated the existence, rises. Normally this threshold is regulated by parathormone. Reciprocally, when a phosphatemia is artificially induced by administration of phosphates, the parathyroids may show hypertrophy. It might follow, therefore, that through the elevation of phosphate level in the blood, nephritis could bring about increased parathyroid activity. Nephritic lesions exist in about 33 per cent of all cases of late rickets.

Arterial, intestinal, endocrine, and nervous lesions are discussed. The hypophysis, thyroid, and islands of Langerhans gave evidence of hyperfunction. The thymus was not unduly atrophied for the age of the patient.

The authors consider that special attention ought to

be paid to parathyroid function in any osseous dystrophy associated with marked osteoporosis. During the terminal stage of the case here recorded there were hypercalcemia and a low blood phosphorus. Here again the authors refer to the views of Brull in linking such a syndrome with renal insufficiency. They conclude that the endocrine system plays only a secondary part in late rickets.

The *conclusions* are as follows:

(1) The anatomico-pathologic substratum for the clinical syndrome of late rickets is characterized by a bony and smooth-muscle dystrophy (arteries and intestine).

(2) The osteopathy is characterized by (*a*) enlargement of epiphyseal cartilages and the occurrence of chondromatous nodules in the metaphyses; (*b*) by a lacunar osteoporosis of the metaphysis corresponding to the type described by Parsons as "moth-eaten" and a halisteresis of the diaphysis; (*c*) by a pseudomalacic osteoporosis, resulting in spontaneous fractures.

(3) The osteoporosis may be due to a lack of vitamin C; to a deficit in the deposition of fats and minerals; to depletion of mineral salts by an ulcerative colitis.

(4) The observed osteopathy was superimposed upon a "hunger malacia," which must be differentiated from a true osteomalacia.

(5) The nervous and mental trouble was probably associated only in that it predisposed to poor appetite and consequent nutritional disturbances.

(6) No parathyroid hypertrophy was demonstrable.

(7) The leiomyopathy concerned the arteries of the kidney and the muscular tunic of the intestine.

(8) The immediate cause of death was acute glomerulonephritis.

(9) The rise in arterial tension was due to hypertrophy of the afibrillar cells of the juxta-glomerular structures.

(10) The existence of a terminal nephritis permits of a doubt as to the rôle of the kidney in the pathogenesis of the type of rickets called "renal"; this presents the same skeletal alterations as simple "late" rickets.

(11) As a result of the retention of phosphorus, the nephritis might be able to provoke a stimulation of the parathyroids such as was noted; but its intensity was too low and its duration too short to give place to a hypertrophy of these structures and to play a rôle in the decalcification of the skeleton.

PERCY J. DELANO, M.D.

Consideration of Certain Dimensional Factors Involved in the Internal Fixation of the Femoral Neck. D. J. Glissan. Australian & New Zealand J. Surg., **10:** 368–373, April 1941.

The author believes that the best method of internal fixation for fracture of the femoral neck is two stainless steel nails that can be accurately placed with the use of only one skiagram.

After the fracture has been reduced, an apparatus consisting of a series of ten parallel Kirschner wire guides, spaced at even intervals, is affixed to the limb by a nail 10 cm. in length, driven into the greater trochanter. An anteroposterior view taken now gives one an exact measurement of the axial length of the femoral neck as well as the location of the axial point (where the axis of the neck meets the lateral femoral surface) in relation to the position of the Kirschner guides. If a Smith-Petersen nail is used for fixation it should be driven through the axial point. If, as the author advises, two stainless steel nails are used, then they should be slightly smaller in dimension than the axial length (due to the oval shape of the head) and driven in a little above and below the axial point.

To guide the nail accurately it is necessary to have determined correctly certain angles in relation to the neck. The *angle of inclination* (or anatomist's angle), formed by the intersection of the central axis of the neck with the shaft, is usually given as averaging 125 to 130° in the adult. The *practical angle*, between the central cervical axis and the lateral surface of the femoral shaft, was found in a series of 37 specimens to average 121°. The inner angle of declination, formed by the central cervical axis and the transverse axis of the pelvis in the interacetabular plane, the author was unable to estimate. It seems almost axiomatic, however, that this angle is reduced to zero when, with the patient lying flat on his back, the limb is fully medially rotated. The central cervical axis is then parallel with the horizon and by the use of a simple plumb bob the direction of entry of the nail can be accurately controlled in this plane. SIMON POLLACK, M.D.

Ankylosing Vertebral Fibrositis. A. Robecchi. Minerva med. **1:** 213–216, March 2, 1941.

In spite of the fact that much has been written about Bechterew's, Pierre Marie's, or Strümpell's disease (ankylosing fibrositis, spondylo-arthritis, ankylopoietic spondylitis, etc.) little is actually known about the exact nature of the lesion or about its primary site or etiology. The author discusses the literature covering these aspects and adds some views of his own, to the effect that the lesion is fundamentally an infectious process to which may be added joint changes which are independent of the alterations in the ligaments. He therefore feels that the best name for this lesion is ankylosing vertebral fibrositis (fibrosite anchilopoietica vertebrale).

E. T. LEDDY, M.D.

THE SPINAL CORD

Meningiomas of the Spinal Cord. Harold F. Buchstein. Minnesota Med. **24:** 539–545, July 1941.

Spinal cord tumors are relatively favorable lesions for surgical treatment. They produce a train of symptoms and signs which, together with various laboratory aids at our disposal, permit their diagnosis and localization with a high degree of accuracy. More important, however, is the fact that most spinal cord tumors are solitary benign lesions which lend themselves to surgical extirpation.

These tumors fall into two histologic groups, meningiomas and neurofibromas.

The term meningioma was proposed by Cushing to designate tumors taking origin from the cranial and spinal meninges. These tumors are believed to develop from embryonic rests of meningoblastic cells, which are seen most frequently in the vicinity of the arachnoid villi but which occur elsewhere in the leptomeninges and in the dura. Conflicting views regarding the histogenesis of the meninges and the tissue structure of these tumors have led to their being known by many names, among them dural endothelioma, meningeal fibroblastoma, and neural epithelioma. Until these arguments have finally been resolved, Cushing's term is preferable, since it is at once simple, descriptive, and non-committal on debated points.

The typical intraspinal meningioma is a discrete, encapsulated tumor having a roughly spherical or ovoid shape. It may arise from the leptomeninges but usually has an attachment to the inner surface of the dura. This area of dural attachment tends to be small in relation to the size of the tumor and to be in the vicinity of a nerve root, a site where there are found structures quite analogous to the arachnoid villi and cell rests of the cranial meninges. The blood supply of the tumor commonly enters through the dural attachment. More rarely intraspinal meningiomas assume a broad, flat shape with an extensive area of dural attachment. Meningiomas displace and compress the spinal cord and its nerve roots, often to a remarkable degree, but

do not invade them. The tumors are soft or firm in consistency and may contain loculations of yellow fluid. A deposit of calcium is common in these tumors, particularly in those of long standing. Spinal meningiomas only seldom penetrate the dura and apparently never arise extradurally. They differ from intracranial meningiomas in that they never involve the bone with the production of hyperostoses.

Although the gross appearance of intraspinal meningiomas is not unlike that of neurofibromas, they may be readily distinguished by the fact that the latter arise within a spinal nerve or nerve root, whereas the meningiomas may displace the spinal nerve roots but do not invade them.

Intraspinal meningiomas occur more commonly in women, the proportion varying from 66 per cent to over 80 per cent in reported series of cases. They are predominantly tumors of adult life, 90 per cent of Learmonth's patients being over thirty years old, and 80 per cent of Elsberg's over forty. Among Ford's series of twenty-one cases of intraspinal tumor in children only one was a meningioma.

Meningiomas occur at all levels of the spinal cord but are rarely found in the region of the cauda equina, a circumstance for which there is no ready explanation. In terms of the vertebral column the distribution of meningiomas in Rasmussen's series was: cervical spine, 16.5 per cent; thoracic spine, 82 per cent; lumbar spine, 1.5 per cent.

The majority of meningiomas of the spinal cord produce symptoms for one to two years before being diagnosed. The symptoms, and their concomitant neurologic signs are in no sense specific for meningiomas but are those common to all spinal cord tumors. They consist in brief of two elements, either of which may predominate, but both of which are usually present: *pain*, due to irritation of nerve roots by the tumor, and sensory, motor, and sphincter paralysis resulting from compression of the spinal cord by the tumor. Pain is characteristically initiated or aggravated by actions which raise the pressure in the spinal epidural space (coughing, sneezing, straining and jarring). It often comes on during recumbency and may be relieved by resumption of the erect posture. The paralysis may progress to the point of complete paraplegia. Either motor or sensory symptoms may be the first to appear. A variety of syndromes may be produced including some which closely simulate systemic and degenerative disorders of the spinal cord, such as primary lateral sclerosis, subacute combined degeneration, and multiple sclerosis.

By the time a lumbar puncture is performed, in most cases manometric studies will demonstrate a complete block of the spinal subarachnoid space (positive Queckenstedt test) and the fluid obtained will contain a moderately increased quantity of protein, often being xanthochromic.

By contrast, neurofibromas of the spinal cord typically occur in men, and have no predilection for any age group. Their first symptom is usually unilateral root pain or other sensory disturbance of segmental distribution.

The level of sensory loss, which may be determined by neurologic examination, is a treacherous guide to the site of the tumor; the sensory level has been noted to rise perceptibly after the performance of lumbar puncture.

Radiographic study of the spine has less diagnostic and localizing value for meningiomas than for many other spinal cord tumors. Whereas 30 per cent of all cord tumors will produce some bony changes, only 10 per cent of meningiomas do so, as compared with 45 per cent of neurofibromas. The changes most commonly seen are erosion of the vertebral pedicles and widening of the vertebral canal at the level of the tumor.

Myelography is of aid; such a study not only locates the meningioma but usually will indicate its intradural and extramedullary character as well. In the event that the tumor is completely obstructing the spinal subarachnoid space a simpler expedient is available in the form of air myelography; with the patient in the upright position air may be seen trapped just below the tumor, outlining its lower border.

Four cases of spinal meningioma are described, and the surgical considerations are discussed.

PERCY J. DELANO, M.D.

TECHNIC

A Research into the Physical Factors Concerned in Indirect Radiography. Paper III. A Simple Method of Detecting Experimentally the Presence of the Phenomenon of Latent Image Reinforcement in a Fluorescing Screen. B. Stanford. Brit. J. Radiol. **14:** 213–214, June 1941.

The method referred to in the title consists of making two exposures of a step wedge. At the second exposure the wedge is rotated 90 degrees. If a latent image is present a tartan effect, showing squares of varying densities, will appear, due to the superimposition of the two wedge images. Application of the method to the G231 screen showed it to be free of the phenomenon.

SYDNEY J. HAWLEY, M.D.

RADIOTHERAPY

MALIGNANT NEOPLASMS

Skin Cancer: Treatment. G. Miescher. Schweiz. med. Wchnschr. **71:** 982–988, Aug. 23, 1941.

The problem of treating skin cancer is largely dependent on the location, which determines whether surgical or radiological methods are to be preferred. The surgical attack destroys the tumor bed, while the radiological preserves it.

Cancers radiologically treated are grouped into three classes: those less than 2 cm. in diameter were treated with a single dose of 1,500–1,600 r (60–100 kv., 20–50 r/m, 0.5 mm. Al filter); those measuring from 3 to 5 cm. were treated twice weekly with 400 r per treatment to a total dose of 2,800–3,600 r (70–180 kv., 10–40 r/m, 0.5 mm. Al to 0.5 mm. Cu); those over 5 cm. received daily, or every other day, 180–200 r to a total of 3,600–4,800 r (70–180 kv., 5–15 r/m, 0.5 mm. Al to 0.5 mm. Cu).

Basal-cell carcinomas of the first group numbered 928, of which 854 showed primary cure, while secondary cure (following recurrence) was obtained in 72 more; in the second group, consisting of 97 cases, 72 were cured primarily, with 10 more secondarily; in the third group, comprising 84 cases, 59 were cured primarily and 11 more secondarily. A statistical calculation of the probability of a "five-year cure" in basal-cell carcinoma showed that this was, for the first group, 99.8 per cent; for the second, 87 per cent; for the third, 70 per cent.

Squamous carcinomas of group 1 numbered 142, with 128 cured primarily and 10 more secondarily; group 2 consisted of 38 cases, with 33 primary cures and 1 secondary cure; in group 3, numbering 31 cases, there were 15 primary and 6 secondary cures. The probability of a five-year cure was thus 96.5 per cent, 87 per cent, and 53 per cent for the three groups.

As a rule secondary treatment in this series was ex-

cision or electrocoagulation. The fact that 10 per cent of the cases required some such procedure indicates that roentgen therapy may not stand entirely alone. Cosmetic results were good, although some tendency to late telangiectasis was seen with fractionated courses.

Electrocoagulation is frequently advisable to clean up the superficial tumor, especially in deeply eroding types. The use of the Chaoul method is another recent progressive step; in 83 of 84 cases in which it was employed primary healing occurred. Radium therapy is not routinely used, but is employed in special cases.

The type of tumor is an important item in determining results; in general, squamous carcinoma may be said to have a less favorable prognosis and to be more prone to metastasis.

Lip cancers received a single large dose (1,600 r). Of 31 cases so treated 26 healed primarily; of 4 recurrences, 3 were later cured by electrocoagulation.

Paget's disease should be treated by fractionated radiation, sometimes with associated amputation of the breast. Melanomas seem best treated by primary electrocoagulation; a third of those treated primarily by radiation recurred. Chaoul therapy may at times give better results here, a total dose up to 2,500 r being given.

Keratoses may be treated with 1000 r, 60–70 kv., 25 cm. distance, no filter, or with 1500 r at 5 cm. distance, if small; for large lesions, fractionated treatment is indicated −400 r × 5 to 6 at daily intervals. Grenz rays may also be used −3000 r at 9–12 kv. for each of three daily treatments. In all cases an accurate diagnosis is essential; biopsy may prevent a serious error.

Since skin cancer seems to be favored by exposure to light, especially ultra-violet light, the avoidance of excessive and continued exposure is advisable. Individual predisposition, however, plays a major rôle.

LEWIS G. JACOBS, M.D.

Cancer of the Lower Lip. Treatment with Radiation. John H. Lamb and William E. Eastland. J. A. M. A. 117: 600–606, Aug. 23, 1941.

There is no part of the body where cancer can be treated by radiation so satisfactorily as on the lip. This is because the blood supply is good, giving a healthy tissue bed, application is easy, and metastasis does not take place until late in 90 per cent of the cases.

Cancers of the lip all seem to arise in certain precancerous conditions, and these the authors consider first.

The lips of many pipe and cigaret smokers show a thin type of leukoplakia, both on the vermilion border and on the mucous surface. At the point receiving greatest stimulation—the so-called "smoker's patch"—there is a gradual thickening into leukokeratosis. Such lesions do not ulcerate or metastasize early but may suddenly begin to grow rapidly with deep proliferation.

Actinic lesions (sun or "fever" blisters, actinic keratoses) were by far the most numerous early precanceroses noticed in the authors' series. Some patients had chronic actinic cheilitis of the entire exposed surface of the lip. With continued exposure to the sun a more persistent lesion is formed in one area. These lesions heal but recur with further exposure. A keratotic scale may form over the blistered area, and later an area of induration may become palpable beneath the epithelium, or a denuded, slightly elevated, crusted, indurated growth may develop. The borders of this growth become elevated and secondary infection may cause it to become fungating. Metastasis has been associated with such lesions even when they measured less than 2 cm. in diameter.

The dry, scaly, senile keratosis which is firmly adherent to the lip and is gray or brownish yellow may develop into a slightly elevated, indurated, button-like lesion which may proliferate in all directions and project 2 or 3 mm. into the substance of the lip before any ulceration takes place. These lesions may form layers of keratin almost comparable to a cutaneous horn and may reach huge proportions without showing any evidence of metastasis.

Leukokeratotic areas may arise from trauma from jagged or broken teeth. They grow rapidly and metastasize early.

Superficial granulomas are the result of scratches, razor cuts, and other abrasions. Secondary infection may lead to extensive local suppuration.

The authors' patients, 318 in number, are classified according to the size of the lesion and the extent of involvement of the lymph nodes.

Group 1. Lesion 1.5 cm. or less, nodes not palpable.
Group 2. Lesion 1.5 cm. or less, nodes palpable.
Group 3. Lesion larger than 1.5 cm., nodes not palpable.
Group 4. Lesion larger than 1.5 cm., nodes palpable.

Most of the patients were in Group 1. The youngest patient treated was twenty years old and the oldest eighty-five. The average age was fifty-three years.

Fair-skinned persons are particularly susceptible to cancer of the lip. One hundred and four patients were farmers, showing again that occupation plays a significant rôle. Only 4 women were found to have cancer of the lower lip. Since exposure to the sun's rays is so important an etiologic factor, sensitive patients must lead a less active life and rest during the time of the most intense sunlight. Sunburn creams in which are incorporated bismuth oxylchloride, quinine, or tannic acid are useful for protection of the lips. The wearing of a large hat is advised; also the growing of a heavy mustache.

The use of tobacco predisposes to leukoplakia, which may eventually lead to carcinoma. There were 132 smokers in this series. Thirteen patients reported previous abrasions with a razor, while many had dental caries or irregular or sharp teeth.

Grading is considered to be of prognostic value. Broders found metastases in 11 per cent of patients with tumors of Grades 1 and 2, and in 66 per cent with tumors of Grades 3 and 4. There are, however, many other factors of equal prognostic value of a clinical nature, such as the type of tumor bed (MacKee and Cipollaro) and the gross appearance and clinical course of the tumor. Biopsy was not practised routinely in this series. With the use of small interstitial radium needles it has become more usual, as local anesthesia is required for placement of the needles and a specimen of tissue can easily be removed at the same time.

Radium therapy has been of two types: surface application and interstitial implantation. For larger growths, two 10 mg. half-strength plaques and one 5 mg. plaque are used in the form of a saddle, the 5 mg. applicator being on top. Two mm. of lead is used as a filter on all plaques. An additional distance of 1 to 1.5 cm. from the skin to the plaque is supplied by enclosing gauze between the filter and the non-metallic rubber. The dose is 1,400 to 2,500 milligram hours, depending on the natural fullness and thickness of the lip.

Interstitial needles vary in size, having an over-all length of 11, 21, or 28 mm. and a wall thickness of 0.5 mm. of platinum. The radium element is distributed so that there is 1 mg. to each centimeter of active length. Needles are placed in parallel rows, 1 cm. apart, running the length of the lesion. A second or third plane of needles 1 cm. inferior to the plane first implanted is used if necessitated by the depth of the lesion. Thus at least 168 milligram hours of radium can be administered to each cubic centimeter of tissue. The outer needles are placed 0.5 cm. beyond the border of the lesion in apparently normal skin. The gamma rays from this small concentration of radium over a more prolonged time seem to fulfill Regaud's concept of bombarding the cells during the stage of mitosis. If the lesion is secondarily infected, filtered roentgen ray treat-

ment is given for several days preceding the placement of the needles, and moist dressings are used.

Superficial lesions of Group 1 are treated by unfiltered roentgen rays (100 kv., 3 ma.), receiving 3 to 5 skin erythema doses (800 to 1,200 r). In addition surface applications of gamma radiation are made, with a 10-mg. half-strength plaque with 2-mm. lead screening at a distance of 1 cm., for 480 milligram hours. Group 1 lesions of the deeper, more infiltrative type receive roentgen radiation filtered through 1 or 2 mm. of aluminum, a total of 800 to 1,000 r being given in divided doses of 300 r every other day. In addition interstitial needles are used for a total of 168 hours.

Lesions of Group 2 are treated in much the same manner as the more infiltrating type in Group 1.

Lesions from 1.5 to 3 cm. in extent, Groups 3 and 4, are treated with interstitial needles and filtered roentgen rays in much the same manner as Groups 1 and 2. Growths larger than 3 cm., if fungating in type and infected, receive preliminary irradiation with filtered roentgen rays, 400 to 600 r daily, for four or five days before the implantation of needles, the factors employed being those previously mentioned. Some degree of telangiectasia and scarring is noticeable in patients with thin, fair skin.

Since the swelling of nodes often proves to be of inflammatory origin, the routine practice of giving high-voltage roentgen rays to the node-bearing areas of all patients with cancer of the lip is not warranted. Patients must be selected by expert clinical judgment for such treatment. For node metastases both surgical intervention and irradiation must be considered. Block dissection is recommended only in selected cases. It is contraindicated, according to Duffy, if the primary lesion is uncontrolled, if the capsule of the node is infiltrated by carcinoma, if cross or bilateral cervical metastases are present, if distant metastases can be demonstrated, or if the patient is in poor general condition.

The authors report a high percentage of cures, which they believe is largely attributable to the fact that 70 per cent of the lesions seen in their clinic are 1.5 cm. or less in diameter and to careful selection of patients for radiation treatment.

Cure of the primary lesion was obtained in every case in which treatment was with interstitial needles or adequate radium therapy was given as described, if the lesion had not been treated previously by inadequate doses of radiation. Among 216 patients treated to 1936 the five-year cure rate was 72.2 per cent. A survey of 22 patients who died showed that more than 50 per cent were in group 4.

The authors divide their series of 318 cases of cancer of the lip into three time periods. During the early period—1924 to 1932—unfiltered roentgen rays and inadequate aluminum- and brass-filtered radium, giving mostly beta radiation, were used. The dose was small, being repeated at six-week intervals, sometimes over nine months' time. Some telangiectasia and radiodermatitis resulted. Large lesions were seldom entirely cured by radiation and other methods were required for their destruction. The rate of five-year cures for the early period was 66 per cent. The total number of cases treated was 158.

In the middle period—1932 to 1935—more filtration was applied to the radium, with an increase in the length of time of treatment. One continuous well filtered application was found to be all that was necessary. The primary lesion was almost 100 per cent curable in this period by irradiation alone.

The late period—1935 to 1941—was characterized by greater use of interstitial radiation. The tongue and other contiguous structures did not receive the pronounced secondary irradiation which was a drawback in the use of the "saddle" applicator employed in the middle period. The five-year survival rate for this period was 88 per cent.

All patients are made to understand that the treatment includes observation every two months for a year and a half after the cure of the primary lesion, and after this period contact is maintained by correspondence. The patients are also requested to make a yearly visit during the rest of their lives.

CLARENCE E. WEAVER, M.D.

Present Status of Treatment of Gynecological Cancer; with Special Reference to Results Obtained Since Introduction of Supervoltage Roentgen Therapy—Statistical Analysis of Results from 1922–1935. George Kamperman. Surg., Gynec. & Obst. **72:** 384–390, Feb. 15, 1941.

The author reviews 845 cases of gynecological cancer treated in Harper Hospital (Detroit, Mich.) from 1922 to 1935 and discusses "on the basis of 5 and 10 year survival curves and other statistical figures the more salient points which have left their landmarks on the routine clinical procedures, thus leading to the present day status in the treatment of gynecological cancer." In 1932 a supervoltage roentgen therapy apparatus was installed in the hospital and since 1933 patients with gynecological cancer have been irradiated with 500–600 kv. constant more or less routinely, so that an evaluation of the influence of this change on the five-year results was possible for a period of nearly three years (1933–35, inclusive).

Of the 845 cases, 636 were cervical carcinoma, 77 carcinoma of the fundus uteri, 171 carcinoma of the ovary, and 31 carcinoma of the external genitals. All fatalities from whatever cause and all untraced cases were regarded as cancer deaths.

Treatment was by surgery and irradiation combined or by either procedure alone, as seemed advisable in the individual case. The usual irradiation technic included a combination of intracavitary radium application and external roentgen therapy. In the earlier years the total radium dosage did not exceed 5,000 mg. hours, with single doses of 1,200 to 2,400 mg. hours. After 1928 this was increased to 7,200 to 10,000 mg. hours for a total dose, the single dose varying from 3,600 to 5,000 mg. hours. Roentgen irradiation—at first with 200 kv. and later 500 to 600 kv. (7 mm. Cu forefilter)—is considered solely as a supplementary measure, to make up the deficiency of radium dosage at various points, especially toward the periphery of the irradiated pelvis. Only those cases unsuitable for surgery or for intracavitary radium application were treated by roentgen rays alone.

For carcinoma of the cervix irradiation has proved to be the method of choice and in recent years operation has been performed only in rare instances. As the chief reliance has come to be placed upon radium applied in the largest tolerable doses, supplemented by supervoltage therapy, the five-year cure rate has reached an average of 35 per cent as compared with 16 per cent in the earlier years of the survey.

In carcinoma of the fundus a combination of surgery and irradiation has been used whenever possible. With increase in radiation dosage the average five-year survival period rose from 30 per cent prior to 1930 to nearly 50 per cent after 1933.

Ovarian carcinoma was treated for the most part by a combination of surgery and irradiation. The use of supervoltage therapy in this group seems to have had no effect on the five-year and ten-year survival rate, which averaged 20 and 18 per cent, respectively, throughout the period of the survey.

In carcinoma of the external genitals treatment was highly individualized, surgical procedures being common for lesions about the vulva, with irradiation frequently the sole procedure for carcinoma of the labia

and vaginal canal. The five-year survival rate was 16 per cent, but none of the patients with vaginal carcinoma lived as long as this.

The author attributes the superiority of supervoltage therapy to at least three factors: First, there is a greater differential action of the radiation with increasing voltages, permitting the administration of a proportionately larger total dose; second, there is an increase in the total energy which can be delivered to obtain the same skin erythema; and third, there is an increase in the depth dose, making possible a larger absorption at the site of deep seated lesions. Clinically this means that a larger total dose can be administered to the carcinoma with less injury to the skin and to the surrounding structures.

Carcinoma of the Vulva. Roscoe W. Teahan and Hoke Wammock. Pennsylvania M. J. **44:** 1268–1274, July 1941.

According to the experience of these writers, surgery is the method of choice in the treatment of carcinoma of the vulva. A radical removal of the lymph nodes and all of the soft tissue surrounding them should be done. The authors believe that the radiosensitivity of the skin and mucous membrane in this region is so great that if sufficient irradiation is given to destroy the tumor the normal tissue will be damaged beyond repair. JOSEPH T. DANZER, M.D.

Malignant Tumours of Tendon Sheaths. E. S. J. King. Australian and New Zealand J. Surg. **10:** 338–353, April 1941.

The author, in presenting 7 cases of primary sarcoma of the tendon sheaths, discusses their differentiation from sarcomata in general and advocates the use of the term synovial sarcoma (Berger: Am. J. Cancer **34:** 501, 1938). His patients were of both sexes, in the 4th, 5th and 6th decades. A history of trauma, following which the original swelling was noted, was often elicited. The tumor usually is slow growing and malignant, with a tendency to grow in the fascial planes as well as along the tendon sheaths. Metastases occur in the regional lymph nodes and also in the liver and lungs.

Grossly the tumor appears to encircle the tendon sheath and in the early stages does not infiltrate the adjacent structures, although later it becomes adherent to these, and small secondary nodules develop. On section it is fibrous, showing white opaque patches; it may contain areas of mucoid degeneration. Microscopically the tumor is shown to be made up of masses of spindle and spheroidal cells simulating fibrosarcoma. The differentiating feature is the presence of small synovial spaces lined by spindle or spheroidal cells and often containing a mucoid material. These "synovial" spaces were found in 5 of the 7 cases reported.

Treatment is generally unsatisfactory. The procedure of choice is surgical excision of the tumor as well as its lymphatic drainage area followed by local radium implantation. Deep x-ray therapy was of no benefit in the author's experience. SIMON POLLACK, M.D.

Squamous Cell Carcinoma Arising in a Chronic Osteomyelitic Sinus Tract with Metastasis. Eugene S. Bereston and Charles Ney. Arch. Surg. **43:** 257–268, August 1941.

Carcinoma arising in an osteomyelitic sinus tract was first reported in 1835 by Hawkins; it has been somewhat more frequently recorded in the last few decades. It commonly occurs in men between the ages of forty and sixty, with a history of an osteomyelitic sinus tract of twenty to thirty years' duration. The most common sites are the tibia, femur, and bones of the foot. In the superficial type a cauliflower mass may appear about the opening; in the deep type there is a foul discharge. External evidence may be absent. Metastases are rare, and when present rarely go beyond the inguinal nodes. These latter are often inflammatory. Amputation is usually curative.

Seven cases with metastases have been reported, and 2 are here added. One patient had pulmonary metastases from a carcinoma (amputated) of the tibia extending into the femur; the other had a bone metastasis from a tumor primary at the knee and involving the femur. The low incidence of metastasis may indicate a low grade of malignancy or it may be that many of the tumors reported as malignant are really pseudoepitheliomatous hyperplasia, a benign overgrowth of the epithelium. White and Weidman stated that it may be impossible to distinguish between these conditions microscopically. LEWIS G. JACOBS, M.D.

NON-MALIGNANT CONDITIONS

Roentgen-Ray Therapy for Benign Otorhinologic Conditions. Matthew S. Ersner. Pennsylvania M. J. **44:** 1418–1422, August 1941.

Roentgen rays are recognized as a valuable therapeutic aid in the treatment of benign otorhinologic conditions. Small doses frequently repeated are most efficacious in acute conditions; larger doses may be used where the condition has become chronic. The relief of symptoms can be attributed "to the fact that roentgen therapy helps the disintegration of lymphocytes, and thus liberates the enzymes, promotes phagocytosis, and in certain conditions aids localization and liquefaction of the tissues, and, last but not least, promotes resolution."

In cellulitis of the external auditory canal an antipruritic is first applied to alleviate itching. After suitable medical tampons are applied, irradiation is given (89 kv., 5 ma., 14″ S.T.D., no filter) for a dose of 100 r. A treatment is given every six days for six treatments. In erysipelas coincidental with mastoiditis about 200 r are given over a large area.

Conductive deafness due to hypertrophy of lymphoid tissue in the region of the epipharynx and around the eustachian tubes responds well to x-ray therapy (135 kv., 5 ma., 14″ S.T.D., 0.25 Cu), 150 r being given once a week for about eight treatments.

The author condemns the use of x-ray therapy in acute suppurative otitis media and believes it is of limited value in acute mastoiditis provided there is ample drainage. Very small doses of x-ray are of value in chronic otitis media. In persistent otorrhea following mastoidectomy x-ray therapy may produce a dry ear after all other methods have failed. Small doses are given twice weekly over the affected area for a number of months.

Cellulitis of the face has responded favorably to x-ray therapy, in doses of 100 r per treatment (89 kv., 5 ma., 14″ S.T.D.).

Acute sinusitis should not be treated by x-ray therapy unless good drainage has been secured; 105 r may be given daily to one of four ports, using 132 kv., 5 ma., 35 cm. S.T.D., 0.25 mm. Cu. Chronic sinusitis responds slowly to irradiation. It is useless in the presence of polyps and should not be used in the atrophic type.

X-ray therapy is definitely contraindicated in cases of active nasal allergy.

Adenitis responds favorably to irradiation, 100 r every other day, over the affected areas.

Surgical parotitis responds rapidly and favorably to irradiation; "100 r repeated at frequent intervals depending on the response invariably brings about a subsidence of the temperature within 24 to 48 hours and an abatement of the edema of the parotids."

JOSEPH T. DANZER, M.D.

Study of Schaumann's Lymphogranulomatosis. P. Di Lorenzo. Minerva med. **32:** 417–420, April 27, 1941.

Schaumann in a series of papers from 1914 to 1936 set up a distinction between benign and malignant lymphogranulomatosis, as a result of which the former is called Schaumann's syndrome. As a matter of fact, a similar syndrome was described by Besnier in 1884. So-called Schaumann's benign lymphogranulomatosis is "a systemic disease, a reticulo-endotheliosis, with lesions involving the lymphatic system, primarily the lymph nodes, the tonsils, the bone marrow, the spleen, the liver and the lungs; it may even involve the skin in various forms, such as that described by Besnier, a lupus pernio, or even as the sarcoid of Boeck." This lesion has been described fifteen times in childhood. The author presents another case in a child of eleven years. E. T. LEDDY, M.D.

RADIATION INJURIES

Radiation Protection in Forty-Five Hospitals. Leonard A. Scheele and Dean B. Cowie. J. A. M. A. **117:** 588–591, Aug. 23, 1941.

The authors visited 45 hospitals of all types, ranging in size from 44 to over 3,000 beds (32 had more than 200 beds) and studied storage and handling of radium, calibration and shielding of roentgen therapy equipment, and technics of use and shielding of roentgenographic and fluoroscopic units. Adequacy of equipment and practices were judged in most instances on the basis of recommendations for protection which have been published by various writers and those in the National Bureau of Standards handbooks on roentgen ray and radium protection. The 0.1 roentgen dose was accepted as the safe daily tolerance dose.

Radium: It was found that lead equivalents of storage blocks were such that overexposure occurred in 16 of the 45 hospitals, and 13 others were classed as borderline. Storage in safes in administration offices was a frequent cause of excessive exposure of nontechnical personnel. Radium in assembled applicators was found outside the storage blocks in more than one-fourth of the hospitals. Fourteen institutions had no L blocks, and 10 had blocks less than 2 inches (5 cm.) in thickness. Four of these were less than a quarter of an inch thick. Instruments for assembly were excellent in 24 institutions. Frequent use of fingers was noted during manipulation. Hands, paper boxes, glass jars, and inadequate lead boxes were used as carriers in the majority of institutions.

Roentgen Diagnosis: Thirteen hospitals had no protection for the operator except that around the tube, and this usually was incomplete or insufficient. Technicians frequently held infants and patients speaking only a foreign language during roentgenography and one received exposures on the hands as high as 35 roentgens while holding a single patient. Other daily exposures ranging from 1 to 5 roentgens were observed.

Open lead glass bowls were found to be in frequent use. Four instances were noted in which the unshielded operator at the control panel was in the direct beam of the tube.

The greatest repeated overexposures were found during fluoroscopy. While the lead glass in the screen provided adequate shielding in all institutions, it was found that the shutters of 30 of the units did not restrict the direct beam to the protected screen area. It was possible for the examiner to receive large doses on his hands if he worked with the shutter wide open and without protective gloves.

Average exposures to the hands of the examiner during fluoroscopy were found to be such that doses could not be held under 0.1 roentgen a day unless gloves with 0.5-mm. lead equivalent were worn as a routine. In spite of this, one-fourth of the radiologic departments possessed no lead rubber gloves, or such gloves were never used. Wearing of pigskin or canvas gloves was found to be frequent, but these offer inadequate protection. Many lead-rubber gloves were found to be old and defective, thus failing to give efficient protection.

Aprons were checked for effectiveness in reducing the exposure hazard, and extreme variations were found in the protective value. Aprons with 0.5-mm. lead equivalents placed on the table top in the direct beam reduce the intensity at the screen to such a level that no fluorescence can be seen on it. Many aprons, however, were found to have lead equivalents well under 0.5 mm. In the fluoroscopic rooms of only 7 hospitals were aprons worn by technicians, although scattering was of such intensity in many instances as to permit them to receive more than 0.1 roentgen a day.

Roentgen Therapy: Thirty-nine of the 45 hospitals had equipment for high-voltage therapy. Only 4 of this group had inadequate shielding.

Calibrations were checked in 37 of the institutions. One-fourth of the calibrations in use had errors of more than 10 per cent. Errors were most often found in institutions calibrating once a year or less. In the hospitals in which registered physicists, radiologists, or staff physicists made the measurements, only one of the calibrations in use was found to be in error. Where technicians and others calibrated, there were errors of more than 10 per cent in most cases.

Injury: Only a superficial study of injuries to workers was made. Blood counts were routine procedures in only 9 institutions. Cutaneous effects varying from atrophy to the formation of epithelioma were noted in 12 radiologists (20 per cent of the radiologists seen) and 5 technicians. Those with injuries had had exposures to radiation varying from ten months to twenty-five years, and the majority had been exposed more than fourteen years.

Summary: It was found that careful compliance with the recommendations in the handbooks on radium and roentgen ray protection enabled even the busiest workers to receive daily doses in the order of 0.02 roentgen or less. However, equipment and practices, as they were found, caused a large number of the workers to receive more exposure than the recommended 0.1 roentgen a day. Too little attention was paid to adequate education and supervision of technical workers handling radium and x-ray equipment. Both radiologists and technicians received considerably more radiation during fluoroscopy than they were aware of. These exposures were the most excessive noted in the survey. It was found that less inherent protection had been built into most equipment and protective devices than radiologists generally realized. The casual finding of 12 injuries among 60 radiologists is evidence of the need for further study of tolerance doses, the problems of shielding of equipment, and operating technics.

[This same material appears in slightly different form, and with illustrations, in J. Nat. Cancer Inst. **1:** 767–787, June 1941.] CLARENCE E. WEAVER, M.D.

Radiation Damage to Tissue and Its Repair. Ernest M. Daland. Surg., Gynec. & Obst. **72:** 372–383, Feb. 15, 1941.

The early reaction to irradiation, *i.e.*, within the first few months after treatment, consists in bronzing of the

skin, endarteritis, and fibrosis of the subcutaneous tissues. This may not be severe enough to cause serious damage. However, if a large artery supplying this damaged area is ligated, complete necrosis of the irradiated field may develop within a few days. Late changes comprise telangiectases, followed by hyperkeratoses in the skin, alopecia, fissures, fibrosis of and later loss of the subcutaneous fat, marked endarteritis of the smaller vessels, and degenerative changes in the fascia. The extent of these late changes depends on the amount of radiation originally given, the time interval, and the region involved.

The most serious of all complications from irradiation is the development of cancer of the skin in the treated area. This may appear as early as two and a half years after treatment or after an interval of many years (eighteen in one of the author's cases).

Treatment of radiation damage must be adapted to the individual case. In general, it may be stated that treatment will be based on removal of tissues which are damaged beyond their own power of repair, on relief from infection, on short-circuits to avoid continual irritation of an involved organ, and on the replacement of tissues by free grafts or flaps.

Twenty-four cases with illustrations are recorded to show the various types of injury and methods of repair. The author concludes that damage to tissues following irradiation may be due to faulty technic, improper dosage or screening, excessive doses particularly for benign lesions, heavy doses in the successful attack on a malignant growth, or to scattering or penetrating radiation of normal tissues around a malignant growth.

When the circulation of a region is poor, the damaging effect from irradiation is greater. After therapy the circulation becomes poorer in the treated area and any ligation of vessels to that region will result in a gangrene. Infection in a treated area may hasten necrosis. The extremities often have deficient circulation and do not tolerate heavy doses well.

Experiences in the Treatment of Roentgen and Radium Cancer. Paul Pfhäler. Schweiz. med. Wchnschr. **71,** 993–996, Aug. 23, 1941.

A rather discursive but interesting discussion of the author's experiences in treating late roentgen injuries of the skin, some in radiologists and others in patients. The changes in all cases were observed years or decades after the responsible exposure. The following quotation gives the author's views as to proper treatment succinctly, "Small ulcers and hyperkeratoses may be electrocoagulated without further treatment. In extensive disease I advise wide excision, principally for this reason, that the removed tissue can then be examined microscopically and also because excision with flap grafting requires much less time for healing than does a large area denuded by electrocoagulation, for which one must allow two to three months." The author adopted a conservative view toward amputation and exarticulations, employing them sparingly. Postoperative care must be given with great patience and persistence. The author has had no recurrences in the grafted areas, and believes that most of the carcinomas from radiation are of the basal-cell variety, with little tendency to metastasize. LEWIS G. JACOBS, M.D.

A Pemphigoid Exanthem Coming on in a Case of Malignant Lymphogranuloma during X-Ray Treatment. A. Maccagno. Minerva med. **32:** 101–104, Jan. 26, 1941.

Pemphigoid eruptions in lymphoblastoma are quite rare. The author describes the clinical course of such a case occurring in a woman of twenty-six, who had mediastinal lymphoblastoma, hyperthyroidism, and signs of neurovegetative disequilibrium. During a course of roentgen therapy, the technical aspects of which were not in any way remarkable, the patient improved. Four days afterward she developed on the legs an eruption (photographs are presented) which spread rapidly and lasted seventeen days; it was diagnosed as pemphigus. A second course of x-ray treatment (total tele-irradiation) a month later was followed in a few days by an eruption which was less extensive and which lasted only a few days. The explanation for this sequence of events is obscure, but the author's hypothesis is that this case is an example of radio-anaphylaxis. E. T. LEDDY, M.D.

Biological Significance of the Tolerance Dose in X-Ray and Radium Protection. Paul S. Henshaw. J. National Cancer Inst. **1:** 789–805, June 1941.

The author lists the main types of injuries produced by radiation, and puts special emphasis on the genetic alterations. Although nothing is known in man as to radiogenetic alterations, experiments on plants and animals show that genetic changes due to radiation follow a non-threshold dose-response relationship. Very small doses produce alterations (gene mutations and chromosome aberrations) in a smaller number than large doses, but there is no minimum dose below which no lesion is produced. For the time being, and allowing for the necessary reserve concerning the genetic injuries, the author proposes the following definition of the 'tolerance dose": "The amount of x-ray or gamma ray energy that a person can receive continuously or at repeated intervals without suffering changes in the blood when the whole body is exposed, or reddening of the skin when local areas are exposed." S. E. LURIA, M.D.

EXPERIMENTAL STUDIES

Some Cytologic Effects of Therapeutic Radiation. Lloyd C. Fogg and Shields Warren. Cancer Research **1:** 649–652, August 1941.

Histologic examination of the Walker rat carcinoma 256 and mouse sarcoma 180 which received 2,400 or 4,800 r, and 2,400 r, respectively, in single doses discloses variable degrees of injury of the tumor cells. There is a gradual increase in the number of cells with multiple centrioles for 24 to 96 hours after irradiation. Inhibition of cytoplasmatic division in the presence of continued division of the nuclei and centrioles is held responsible for this effect. Approximately 90 per cent of the mitotic figures observed between 18 and 96 hours following the exposure are abnormal. If cell division is delayed until after 120 hours, the effects of radiation have been sufficiently reduced to permit normal mitosis. MILTON J. EISEN, M.D.

Further Studies on the Effect of X-Rays on a Tumor of Known Genetic Constitution. M. C. Reinhard, S. G. Warner, and H. L. Goltz. Cancer Research **1:** 653–655, August 1941.

Additional data are reported on the production by roentgen radiation of a permanent genetic transformation in a transplantable carcinoma of the mouse. The tumor, which originated in a member of the pure strain Simpson mice, is normally transmissible in 100 per cent of the animals of this strain, but fails to grow in other mice. After the administration of a dose of 25 r *in vivo*

it was possible to transplant the tumor successfully in 34 per cent of normally resistant C57 black mice. The carcinoma, nevertheless, remained transmissible in 100 per cent of the original Simpson strain. When the amount of radiation was increased, there was a concomitant rise in the percentage of takes in black mice. Following doses of 400 r tumors resulted in 70 per cent of the inoculated animals of the latter strain, but a decrease in the percentage of positive transplants occurred after greater doses. The change produced by radiation appeared to be immediate, as evidenced by the consistent transplantability of fragments of tumors which received 200 r *in vivo*, directly following irradiation, and after one, three, five, and seven days, in 40 per cent of C57 black mice.

MILTON J. EISEN, M.D.

MISCELLANEOUS

Explosion and Fire Hazard of Anesthetics in the Presence of Roentgenologic Apparatus. Barnett A. Greene. Am. J. Roentgenol. 45: 737–743, May 1941.

The author points out that while the danger of operating roentgen-ray equipment near combustible anesthetics has long been known, explosions and fires due to this practice still occur. Ten examples of such accidents are recorded. In 9 of these the roentgen procedure was for diagnostic purposes, in one for therapy. The anesthetics involved were ether in 8 instances, ethyl chloride in one, and cyclopropane in one. Where an ether-air mixture was used no injuries resulted. Two patients died, and 2 more were seriously injured, in those cases involving ether-nitrous oxide-oxygen. One cyclopropane-oxygen explosion caused a slight burn of the patient's cheek and a serious injury to the anesthetist. All the surgical indications were injuries or disease of parts of the body readily anesthetized by local or regional blocks.

The author points out the many possible sources of a spark in roentgen-ray rooms and quotes manufacturers of x-ray apparatus to the effect that very few, if any, of the modern shock-proof roentgen outfits in use today are completely spark-proof, though the widespread adoption of such apparatus has certainly made for greater safety. While a completely spark-proof roentgen-ray room is possible, it is less practicable, more expensive, and less safe than the use of non-combustible anesthetics. The surgical and diagnostic procedures requiring the presence of roentgen rays during anesthesia are more readily and safely performed under the non-combustible agents in the hands of a competent anesthetist than under ether anesthesia given by a technician or novice-anesthetist.

In the forthcoming new edition of the *Recommended Safeguards for the Installation and Operation of Anesthetical Apparatus Employing Combustible Anesthetics*, to be issued by the National Board of Fire Underwriters, the warning is again to be stated: "In the operating room and elsewhere the use of X-ray machines in the presence of any combustible anesthetic should be prohibited."

Violation of this dictate of thorough investigation and sound judgment is likely to cause, sooner or later, the erring hospital or physician to regret a completely avoidable injury, death, or malpractice claim.

S. M. ATKINS, M.D.